JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 32 AUGUST 15, 1942 No. 8

Cosmic emotion.[1]

PAUL R. HEYL, National Bureau of Standards.

Every one of us is born into a wonderland —the universe in which we live and move and have our being, and which, from the dawn of human thinking, has exerted a profound fascination upon the mind.

Man's reaction to the riddle of the universe is an interesting study, leading to a conclusion perhaps rather unexpected—that in this respect modern man differs less from his primitive forbears than might be supposed. An analysis of the cosmic emotion evidenced in the earliest human records reveals six principal elements in its composition, five of which are to be found in modern man, all qualitatively unaltered, though in some cases much intensified. The sixth element, though strong in earlier times, has now almost faded away, but its place has been taken by a seventh element of distinctly modern origin.

First and foremost among these permanent elements we may place wonder and its invariable concomitant, curiosity. The presence of these elements in very young children testifies to their ancient racial character. It is recorded that the physicist Clerk Maxwell, in his early years, was continually asking his elders, "What is the go of that?" Every parent can match this from his own experience, and primitive man doubtless asked many such questions with no one to answer them. But curiosity, like hunger, becomes stronger the longer it remains unsatisfied, and lacking an answer it will manufacture one for itself.

The records of the past are full of such guesses at the causes of natural phenomena, mostly anthropomorphic in character. The stormy waves of the sea were caused by the wrathful strokes of Neptune's trident; the attraction of the magnet for iron was due to an indwelling spirit, and the thunderbolts of Jove still live in poetic parlance. Gradually, however, man learned that there was one source from which he could obtain an answer to his questions—Nature herself. It has been well said that an experiment is a question put to Nature, and it is interesting to reflect that the experimental method and the growth of modern science have their origin in the urge of these two primitive instincts—wonder and curiosity.

Primitive though they may be, these elements are still with us. Time has but strengthened and ripened them and widened their field of application. It is no longer necessary that an occurrence be rare or spectacular to excite our wonder. We have learned that the simplest and most commonplace natural phenomenon, even the falling of an apple from a tree, is, when we stop to think about it, as Newton did, wonderful past all speaking. Nor is this recognition of the wonder of the commonplace confined to scientific men.

Seventy years ago, some of William Kingdon Clifford's most successful popular addresses on science were given before audiences of London working men. It is true that Clifford was the greatest master of lucid exposition in our language, but some of the credit must be given to the receptive audiences. It is unthinkable that even a Clifford could interest, say, a primitive group of Australian black-fellows in such subjects without the liberal use of experiments according to the classical definition—involving a bright light or a loud noise.

Several years ago I was asked to given an

[1] Address presented to the Washington Academy of Sciences on March 19, 1942. Received March 19, 1942.

address before the scientific staff of the General Electric Research Laboratory at Schenectady, and also to make a popular broadcast from their radio station. As a subject for the address to the staff I suggested: "Old and New Ideas about Gravitation," and for the radio broadcast: "Practical Suggestions for Improving the Acoustics of Buildings." I was advised by the management of the radio station to use the same subject for the broadcast that I had chosen for the staff meeting, as their experience told them that it would excite the greater popular interest.

The third element in man's cosmic emotion is reverential awe. This also dates back to remote antiquity, as is evidenced by the world-wide prevalence of sun worship. With the passing centuries this element has lost none of its strength. It has been a favorite theme of the poets, ancient and modern. The words of the Psalmist are familiar to us all:

> The heavens declare the glory of God; and the firmament sheweth his handywork.
> Day unto day uttereth speech, and night unto night sheweth knowledge.

Three thousand years later Tennyson expresses the same feeling:

> Flower in the crannied wall,
> I pluck you out of the crannies,
> I hold you here, root and all, in my hand,
> Little flower—but *if* I could understand
> What you are, root and all, and all in all,
> I should know what God and man is.

Closely connected with this element of reverential awe and, in fact, a corollary to it, is man's feeling of his own insignificance as compared with the physical universe. David gives expression to this also:

> When I consider thy heavens, the work of thy fingers,
> The moon and the stars, which thou hast ordained;
> What is man that thou art mindful of him?

With the growth of our knowledge of the universe this feeling of our own physical insignificance has been greatly intensified. It is perhaps not generally realized how small the ancients believed the universe to be. The Greeks placed the abode of the gods no farther away than the summit of Mount Olympus. Omar Khayyam complains of his cramped quarters:

> And that inverted Bowl they call the Sky,
> Whereunder crawling coop'd we live and die

A legend of the days of Mohammed tells how the Prophet made a round trip to heaven and back in one night, mounted on a miraculous steed, to confer with Allah about the number of prayers to be required of the faithful. Even allowing for the element of the miraculous, such a legend could hardly have taken root and flourished in the environment of our modern ideas of the size of the universe. Contrast the ancient concept of the universe with that of the present day, and we can begin to appreciate how much this feeling of physical insignificance has been intensified.

But no matter how insignificant an individual may feel, there is a certain measure of compensation in feeling one's self to be a member of a large group, and the larger the better. For this reason speculation as to the possibility of intelligent life elsewhere in the universe has been particularly attractive to our earthbound race.

A generation ago there was much discussion of the question of possible inhabitants of the planet Mars. Little is now heard of this in scientific circles. Cosmically speaking, life as we know it is a delicate hothouse plant, capable of existing only within rather narrow limits of temperature and composition of atmosphere, and every increase in our knowledge of these conditions as they prevail on Mars has made the existence of intelligent life on that planet more and more improbable. The same applies to all the other planets of our solar system; they are either too hot or too cold, or their atmospheres lack sufficient oxygen and water.

But are not the stars of heaven suns like our own, and among these millions of suns and their attendant planets is it not reasonable to suppose that there may be a few thousand bodies as well fitted as our earth to sustain human life?

For this question astronomy has rather a staggering answer. It is true that these stars are suns, but it does not necessarily follow that they all have planetary systems. In

fact, it is now regarded as quite possible that but very few of them are so favored. Jeans goes so far as to call our system a freak system, and to suggest that there may be but one other like it.

There is today no perfectly satisfactory and generally accepted theory of the origin of our solar system. That the planets once formed part of the sun is beyond doubt, but how they came to be detached from it is still uncertain. Laplace's nebular hypothesis, after a reign of more than a century, had to be abandoned, as it was found that it failed to satisfy an important condition of celestial mechanics. Several other hypotheses have been proposed, none of which is completely satisfactory, but all of which agree in ascribing the origin of the solar system to a close approach or a grazing collision between our sun and another star. And so widely scattered are the stars of heaven that such an encounter could not be expected to occur oftener than once in ten million million years. Our little colony of life may be only an ant hill in a vast desert, and man's feeling of physical insignificance is intensified by a sense of cosmic loneliness.

These four elements—wonder, curiosity, reverential awe, and physical insignificance, have been features of man's cosmic emotion since earliest times, and bid fair to remain so as long as our race shall last. Such changes as time has wrought in them have been quantitative, in most cases an increase in intensity. To these four is to be added a fifth, which, though prominent in bygone years, has now almost faded away—superstitious fear.

During the Middle Ages it was the universal custom in Europe to ring the church bells on the approach of a thunder storm with the idea of frightening away the Prince of the Power of the Air and his attendant demons. Bells are still to be seen in old churches bearing inscriptions such as: "I break the lightning," or "I put demons to flight." In earlier days this fear often prompted human sacrifice in times of famine or pestilence, to appease the supposed anger of the gods. In some places, on the principle that prevention is better than cure, a human victim was sacrificed annually in the spring of the year in order to ensure fertility of the fields during the coming season. In our time this element of superstitious fear has all but disappeared, but its place has been taken by another element, qualitatively new and of distinctly modern origin.

The supposed agency of demons and spirits in natural phenomena has, with the modern development of the sciences, been replaced by physical causation and laws of Nature. These laws are now so well understood that we can, for instance, predict with reasonable accuracy a clear or rainy morrow, and with perfect accuracy an eclipse of the sun. Passing from the macrocosm to the microcosm, we have learned the cause of many diseases and the cure for some of them. We prefer lightning rods to church bells and antitoxins to incantations. Though much of Nature is still beyond our prediction or control, it is no mean attainment to have achieved a sufficient intellectual mastery of our environment to begin to understand it. And as we pass the Cosmos in review before the mind and reflect that of all Nature man alone has achieved this mastery, there wells up within us a sense of intellectual superiority that goes far toward alleviating our feeling of physical insignificance. Man may be but the merest speck in the universe, yet in his intelligent comprehension of it is he not but little lower than the angels?

In the year 1875 the physicist Maxwell gave this growing feeling of intellectual superiority a powerful stimulus.

The more we have learned of the laws of Nature the more profound is the respect which they have inspired. Like the laws of the Medes and Persians, they alter not. We may defy them, but no one is sufficiently influential to escape the consequences of his defiance. Such progress as we have made in the control and utilization of natural forces has been attained by making allies of some of them, and cunningly pitting one force against another, as, for instance, the air resistance to a parachute against the force of gravity on the aviator. Imagine then the effect produced in the scientific world when Maxwell pointed out that it lies within the

power of intelligence to reverse the action of one of Nature's fundamental laws, known as the second law of thermodynamics.

According to this law heat, like water, when left to itself, naturally runs downhill. If we put a cold spoon in a cup of hot tea the spoon becomes warmer and the liquid cooler. This transfer of heat from the higher level of temperature to the lower will continue until both spoon and liquid reach a common level of temperature. It would be against all experience to expect the spoon to become colder and the tea hotter.

It is true that water can be raised from a lower to a higher level, but only by expending work upon it, as, for instance, by lifting it in a bucket or by working a pump handle. And it is possible to make heat run uphill from a cool body to one that is warmer, but, as with water, only at the price of expenditure of work. But Maxwell showed that it is theoretically possible for intelligence to bring this about without expending any work. The practical difficulty is that we lack for the present a vision keen enough and a touch delicate enough to see and handle the single molecules of which all bodies are composed.

Of the three states of matter, solid, liquid, and gaseous, the structure of a gas is the simplest, and it was upon this that Maxwell based his demonstration. Imagine a swarm of bees flying about in a closed box, colliding with each other occasionally, and rebounding from the walls of the box. Suppose also that some of the bees are flying rapidly and some slowly, while the majority are flying at intermediate speeds, and you will have a good idea of the structure of a gas. The molecules of which a gas is composed are, of course, very small, far too small to be seen with a microscope, but their number is so great and their velocities are so high (of the order of a mile a second) that the pressure produced by the joint impact of millions of these molecules upon the walls of the containing vessel is by no means inconsiderable. This it is, in fact, which sometimes bursts a steam boiler.

When we say that a gas or a vapor is "hot" it is our way of expressing the physical fact that its molecules have a higher velocity than those of a cooler gas. The molecules of the hot steam inside the boiler are moving much more rapidly than those of the air outside, and the pressure on the boiler plates from within is greater than the counter pressure from without. The wall of the boiler is supposed to be strong enough to take care of this difference of pressure, but if the water is kept boiling vigorously the number of steam molecules continually increases until their joint impact is so great that the boiler plates give way.

Returning to Maxwell's argument, imagine a gas contained in a vessel divided into two parts by a partition, and suppose the gas on each side of the partition is at the same temperature, that is, the molecules on each side have the same average velocity. Suppose that there is a tiny door in the partition, in charge of a little intelligent being who can see the molecules and distinguish between the rapidly moving and the slow ones. When this being sees a rapid molecule in the right-hand compartment headed for the door it is his duty to open the door and let the molecule pass into the left compartment, but he is to keep the door closed against slow molecules on the right. Conversely, he is to allow only the slow molecules to pass from the left to the right. By this sorting process the average velocity of the molecules on the right will continually decrease, while that of those on the left will increase. The effect of this will be that the temperature of the gas on the left will rise while that on the right will fall, and heat will run uphill.

This argument of Maxwell's is something more than an interesting fairy tale. It teaches us that when, from our experience, we have formulated what we call a law of Nature we are not to regard this as the last word on the subject; that Nature's way of working when left to herself may be radically altered when intelligence takes the reins. Nor is the necessary degree of intelligence to be regarded as an unattainable ideal. Much progress has been made in this direction since Maxwell's day, and more will be made in the future. While we are not yet able to see molecules we can do many things with them without seeing

them. We can, for instance, count the number of molecules in a cubic foot of a gas with at least as great accuracy as we can count the population of New York City.

There is much justification for the feeling of intellectual superiority with which man surveys his environment. The intensity which this feeling may attain is well illustrated by an old story.

It is said that at one time an astronomer discovered a new star, which he found by his measurements to be approaching the earth with a high velocity. He calculated that it would strike the earth in a few months. He did not announce his discovery, fearing to witness the orgy of lawlessness and despair which might follow such an announcement, but night after night he studied this approaching doom, fascinated by it. One night he spoke out and addressed the star as follows:

"I know that you will soon destroy me and everything living, but I can calculate the day—nay, even the hour—when this will happen, while you are but a blind brute thing, and I would not change places with you!"

There is one more element in our cosmic emotion which we shall consider. Man finds himself in a wonderland which excites curiosity and inspires awe. He feels his own physical insignificance and the transitory nature of his stay, and yet he is not content to be a mere "super" in the cosmic drama, but feels qualified for a speaking part. He wants to be remembered, he feels an urge to leave his mark on the universe, at least on such portion of it as is within his reach.

We can trace this element far back into antiquity. This it was which built the pyramids, and which prompted the proud boast of the Roman emperor who said: "I found Rome of brick and left it of marble." In modern times this element has suffered a qualitative change, and assumed a form less materialistic and more altruistic, but the primitive urge is still there. When the founder of the Smithsonian Institution made his will in which his estate was left to the United States of America "for the increase and diffusion of knowledge among men," his solicitor expressed surprise at this unusual bequest. Smithson replied: "My name will be remembered among men when the Percys and Northumberlands are forgotten."

But after all, such monuments, physical or intellectual, can affect only a tiny fraction of the universe—our earth and its inhabitants. In ancient times, when the earth was regarded as the most important part of the visible universe, one might reasonably feel that in beautifying a city or in bettering human society he had done something of cosmic importance, but with our broader outlook the case is different. Not that this detracts in the slightest from the laudable character of such efforts, but considering our cosmic insignificance all such efforts must be recognized to be of but local and temporary importance.

But there are times when all of us find it a relief to think qualitatively rather than quantitatively. Archimedes, that pioneer mechanical engineer, is reputed to have said "Give me a place where I may stand, and I will move the earth." The modern engineer does not even ask for a place to stand, for he knows that by merely shooting a bullet in an easterly direction he can (to a microscopic extent) play the part of Joshua and lengthen the day. Moreover, he knows that (still qualitatively speaking) he can perform actions whose results reach far beyond terrestrial limits. When he strikes a match to light his cigarette as he walks down the street, he knows that he has started light waves, some of which will travel outward and onward in space, perhaps forever.

With increasing knowledge of the universe our eyes have been opened, and we see that our actions may sometimes have a small measure of cosmic scope. It is inevitable that this should lead to speculation as to the possibility of broadening and increasing our cosmic reach. But here we leave the realm of fact and enter that of fancy. It is an attractive realm, as we all know, and by your leave I will tell you another story.

As I journeyed through the world I came to the shore of an ocean reaching far as the eye could see. The water of this ocean was

colorless and transparent and was ceaselessly in motion; even in parts where there were no breakers the water was continually moving in currents. And as I walked along the shore I noticed that there was no living thing in the water, not even a blade of seagrass; nor did any living thing appear on the beach as far as I could see inland. Thus I wandered ever along the shore of the ocean, watching for some living thing, but finding none.

At length, after many miles of traveling, I came to a place where the sea ran inland, forming a little pool wherein the ceaseless currents played. By the side of this pool there lay an old man, gazing intently into the beautiful clear sea water, and my heart was glad at the sight of a living thing.

"Tell me, father," said I, "what is the name of this ocean? And what curse is laid upon it that there is no living thing in its waters?"

The old man looked at me for some moments without speaking. Then he said, apparently ignoring my first question:

"There are living things in it, but they are few."

"I have traveled many days," said I, "but I have seen none."

"When I was your age, my son," said the old man, "I traveled many months before I found them, and I have lain here watching them ever since."

I looked in the pool, and I saw amid the ceaseless water currents a swarm of living things, hollow, clear-walled creatures, some like single bubbles, some like a heap of bubbles fused together; and the sea water within them was colored a beautiful rich tint, which was new to me. I saw that in those creatures which were composed of many bubbles the color was deep, while in the simpler ones the color was paler, and in the single bubbles I could detect no color at all. I watched the creatures swimming about and pulsating rhythmically, and I said to the old man:

"They are beautiful! And are these the only living creatures in the ocean?"

He shook his head. "I do not know. The ocean is so vast—there may be others—but I have found none."

I looked again in the pool, and I saw that some of the creatures lay still, and their color was paler than that of their fellows of like degree of complexity. The old man said: "They are sleeping." And I saw one creature which, from its complexity, should have had the deepest color of all, but it lay motionless and colorless; and the old man said: "It is dead."

I asked the old man: "What gives to the water within the living creatures its color? Do they secrete coloring matter?"

He answered: "I thought so when I began to study them, but it is not so. Do you see the hairs that line their internal cavities?"

I looked, and I saw that the creatures had little hairs within, and that these hairs were constantly moving, beating and churning up the sea water within. The old man said: "When the sea water is beaten thus it suffers a subtle change and becomes colored."

And I said: "Why then is not the whole ocean colored, since it is ceaselessly beating upon its shore?"

The old man said: "I do not understand it; but it seems that it becomes colored only when it is stirred up by living creatures."

As I silently mused over this my ear caught the sound of a faint chirping. The old man said: "It is made by the creatures in the pool. The more complex ones are able to utter sounds, and the highest of all are even able to communicate with each other by this means."

"They talk!" said I."Then they must think!"

"Ay, that they do," said the old man, "and strange and sad are some of their thoughts; for in the years that I have studied them I have come to understand a little of their language. For instance, this beautiful color is to them the very essence of the pleasure of their lives. The deeper colored pity the paler, and pity most of all those single bubbles which appear devoid of color."

"Are they really colorless?" said I, "Or is their color only so pale as to be imperceptible?"

The old man bade me look again into the pool.

"Do you see," said he, "how the most complex and active creatures, having many hairs moving, are the deepest in color, and how those with fewer hairs to churn the water are paler? Are the single bubbles totally devoid of hairs?"

"No," said I, "they have a few, and these move slowly."

"What think you then? Are these devoid of color, or is it simply a question of degree?"

I felt that my question was answered.

"Ay," continued the old man, "it is a question of degree; for once or twice in the years that I have watched them I have seen single bubbles, under stress of great excitement, churn the water within them so vigorously with their few hairs that it assumed a pale tint."

Then I said, remembering how I had seen the sleeping ones and the dead one: "The depth of color in any creature seems to be proportional to its bodily activity; and, among different creatures, to their complexity."

"Right," said the old man, "and this fact has been recognized by the most complex creatures themselves."

I said: "When the creatures sleep or die, and their color fades, what becomes of it? Is the change produced by beating the sea water so unstable that when the beating ceases the water reverts to its colorless condition?"

The old man looked grave. "So I thought at first, and many a sad hour have I passed thinking of the labor spent in producing this beautiful color, so unstable that it was doomed to perish with the ceasing of the labor that produced it. But," and here his face brightened, and he spoke with assurance, "it is not so. This change once produced is permanent; it can never be undone."

"But what then becomes of the color?"

He pointed to the pool, and I looked in. One of the most deeply colored creatures was just falling asleep. Slowly and still more slowly moved the hairs within it, and its color gradually faded. I watched closely, but I could not see where the color went. Then there came an instant when the ceaseless wash of the currents slackened, and in that instant I saw the water about the creature tinged with the beautiful color. I looked up at the old man.

"Ay," said he, "the color is permanent; but the colored water continually diffuses through the creature's body, waking or sleeping, and is dispersed and diluted in the vast ocean. When they sleep their motion is so far reduced that diffusion renders them pale; and when they die they become absolutely colorless. But the color does not die, the beautiful color—no, it cannot!"

"And do they know this?" said I, pointing to the pool. His face again became grave.

"I find that there is a great difference of opinion among the most complex of them. They all realize that it is this color that makes their lives worth living, and they recognize that its intensity is proportional to their bodily activity. They have an instinctive feeling that the color is permanent, but they are sorely puzzled to account for its fading during sleep and its disappearance at death; so that some say that this instinctive feeling of the permanence of the color is a delusion; that the color is really a most unstable thing, and that colored sea water can exist only within a living organism. This conclusion they sorrowfully accept and make the best of it. Others there are who refuse to accept it, and who cling to their instinct." And the old man sighed as he looked at the restless wash of the water in the pool. Presently he said:

"How long will it take, think you, until the whole ocean becomes of this beautiful color?"

I said, "If there be other creatures elsewhere, and many colonies of them—"

"Nay," said he, "I know not if there be such—I hope—but how long?"

I looked long and silently in the pool. Then I said:

"I see some creatures that are very pale; and they are not asleep, for they are moving about."

The old man's brow grew dark. "These are lazy ones," said he. "They have allowed themselves to become discouraged, and say: 'Why should we labor and beat our hairs to produce a color which must perish

with us?' These are they that retard by just so much the coloring of the ocean."

"Nay, father," said I, "be not angry with them. It is but natural. Remember that they do not know."

"True," said he, and his face grew kind and pitiful, "they do not know."

Said I: "Suppose some great falling rock should crush these creatures out of existence?"

"But the color!" said the old man, "the color cannot be crushed out of existence! And the ocean is so vast—there may be other colonies elsewhere; and even if there be none now, they may in time arise as this colony has done, I know not how. The ocean will be colored!"

I was silent a long time. Then I happened to think of my first question, which still remained unanswered.

"Tell me, father," said I, "what is the name of this ocean?"

"I have never heard but one name for it," said he, "and that is the name given it by these creatures themselves. 'Tis a strange name; there is no exact equivalent for it in our language. The nearest is Energy-of-the-Universe."

"And what do they call this beautiful color?"

"They are not agreed upon a single name. Some call it Consciousness, and some call it Soul."

PALEONTOLOGY.—*New genera of North American brachiopods.*[1] G. ARTHUR COOPER, U. S. National Museum.

In preparing the brachiopod chapter for the forthcoming "Index to North American Fossils," the writer encountered a number of nomenclatorial problems which are here adjusted. It also became evident that a number of new generic names should be proposed for groups of species not yet adequately designated. The generic diagnoses are given herewith without illustration, but most of these genera will be well figured in the forthcoming book. Besides the adjustment of certain homonyms and corrections of printer's errors, reasons for revival of erroneously suppressed names are given. Inasmuch as the "Index" will be in constant use by students the suggested changes should make for clearer understanding and stability in brachiopod nomenclature.

ADJUSTMENT OF HOMONYMS

Callipleura n. name, to replace *Cyclorhina* Hall and Clarke (1894, p. 146); not Peters, 1871, mammal. Genotype: *Rhynchospira nobilis* Hall, 1860.

Plectospira n. name, to replace *Ptychospira* Hall and Clarke (1894, p. 112); not Slavik, 1869, gastropod. Genotype: *Terebratula ferita* von Buch, 1834.

Pustulina n. name, to replace *Vitulina* Hall (1860, p. 72); not Swainson, 1840, gastropod. Genotype: *Vitulina pustulosa* Hall, 1860.

Trigonirhynchia n. name, to replace *Uncinulina* Bayle (1878, pl. 13, figs. 13–16); not Terquem, 1862, echinoderm. Genotype: *Uncinulina fallaciosa* Bayle, 1878.

Barroisella campbelli n. name, to replace *Lingula subspatulata* Meek and Worthen, 1868 (p. 437, pl. 13, fig. 1), the designated type of *Barroisella*, not *Lingula subspatulata* Hall and Meek, 1854–56.

ADJUSTMENT OF SYNONYMY

Dictyonina n. name, to replace *Iphidella* Walcott, 1912, not Walcott, 1905 (equals *Paterina*). In 1872 Billings proposed the genus *Iphidea* with *I. bella* Billings as genotype. The following year Meek proposed the genus *Micromitra* with *Iphidea* (??) *sculptilis* Meek as genotype. This name was not proposed as a substitute for *Iphidea* as suggested by Schuchert and Levene (1929, p. 69, 84) but as a separate genus. Such substitution did take place in 1905 by Walcott (p. 304), who distinctly states that *Iphidella* is proposed to replace *Iphidea* of Billings (not Bayly). From the list of species placed under *Iphidella* by Walcott it is clear that he had a very broad conception of the

[1] Published by permission of the Secretary of the Smithsonian Institution. Received Apr. 21, 1942.

genus. In 1912 Walcott (p. 359) redefined the genus and selected another type species, *Trematis pannulus* White, a procedure contrary to the rules of nomenclature. The type of *Iphidella* is the type of *Iphidea*, i.e., *Iphidea bella* Billings. The genotype of *Iphidea* was placed by Walcott in the genus *Paterina*, which was proposed by Beecher in 1891 with *Obolus labradoricus* as genotype, a species that Billings (p. 478) had already assigned to *Iphidea*. It is therefore apparent that *Iphidea* and *Paterina* are generically identical. Inasmuch as *Iphidea* was stillborn, the name *Paterina* must now be used for these shells. *Iphidella* thus becomes a synonym of *Paterina*, leaving Walcott's *Iphidella* without a name, for which *Dictyonina* is proposed.

REVIVED NAMES

Craniops Hall (1859, p. 84) revived and substituted for *Pholidops*. The name *Craniops* appeared first in a list under a heading "Changed Names, Remarks, etc." and was used for the species *Orbicula* (?) *squamiformis* Hall. Its next use was in the advance copies of the *Paleontology of New York* 4. 1867, but did not appear in the final copy. In 1860 (p. 92) Hall published the name *Pholidops* as a new genus and cited *Orbicula* ? *squamiformis* as the first species, and this was later fixed as type by S. A. Miller, 1889. Inasmuch as *Craniops* and *Pholidops* are exact and objective synonyms, the former name has priority over the latter. The use of *Craniops* in a list with a described species was a valid proposal of a name at that time.

Stenocisma revived and substituted for *Camerophoria*. The conditions under which this name was proposed and the subsequent history are discussed fully by Dall (1877, p. 65) and need not be repeated here. Conrad clearly designated *Terebratula schlotheimi* von Buch as type of his genus and this designation must stand.

Orthambonites revived and used for certain brachiopods hitherto referred to *Orthis*. *Orthambonites* Pander, 1830, type *O. transversa* Pander, is to be used for costate Orthidae having both valves convex. The genus generally has been regarded as a synonym of *Orthis*, but the latter was restricted to species of the type of *O. callactis* with concave dorsal valve. The writer therefore revives the name *Orthambonites* for the biconvex species common in the Lower and Middle Ordovician of this country and Europe.

Resserella replaces *Dalmanella* as restricted by Schuchert and Cooper. The status of *Dalmanella* was thrown into confusion when Schuchert and Cooper (1932, p. 126) erroneously stated the type species to be *Orthis testudinaria* Hall and Clarke, not Dalman, equals *O. rogata* Sardeson. According to the rules of nomenclature the type should be regarded as the species named by Hall and Clarke, i.e., *O. testudinaria* Dalman. As thus restricted a single species (*Dalmanella edgewoodensis* Savage) in this country conforms strictly to the type. This leaves many species hitherto referred to *Dalmanella* without a generic name. Öpik (1933) claims these species to be referable to *Onniella* Bancroft, but according to the writer's view most of them are not congeneric with *Onniella*, which is restricted, as at present known, to a few Richmond species. The Black River and Trenton Dalmanellas actually are conspecific with *Resserella*. Restriction of *Dalmanella* to species of the type of *D. testudinaria* makes Bancroft's genus *Wattsella* a synonym of *Dalmanella* s.s.

Torynifer recognized. This name was proposed by Hall and Clarke (1894, pl. 84) for a fragment of a dorsal valve which exhibits a peculiar concave hinge-plate and which they felt was so unusual that it must be named despite its fragmentary condition. In the National Museum the writer discovered specimens almost identical with Hall and Clarke's fragment, which come from Pierce Springs, Larue County, Ky. These prove *Torynifer* to be the dorsal valve of *"Reticularia" pseudolineata* (Hall). *T. criticus* is thus a synonym of *"R." pseudolineata*, and the generic name may be applied to the American Mississippian "Reticularias." *Torynifer* possesses a deeply concave undivided hinge-plate attached to a long median septum, a feature unlike that of the British type of *Reticularia*, according

to diagrams of the genotype published by George (1932). In these no septum is indicated and the hinge-plate is divided like that of the martinias. *Torynifer* also possesses a flat deltidial plate in the ventral valve which is not indicated in the British *Reticularia*. The writer therefore proposes to use the name *Torynifer* for the American Mississippian species of *Reticularia*.

CORRECTIONS

Septothyris Cooper and Williams, 1935.—Although this genus is monotypical, a printer's error prevented an unambiguous designation of the type. The type designation does not appear under the heading "Genotype," which is in its correct place but is incorrectly offset as an incomplete center heading "*Septothyris* Cooper and Williams, n. sp." The fact that the incomplete center heading is the actual designation inadvertently offset and minus the specific name should be obvious. The type of *Septothyris* is *S. septata* Cooper and Williams.

Trematorthis Ulrich and Cooper 1938.—In Ulrich and Cooper's "Ozarkian and Canadian Brachiopoda" the heading "*Tremorthis* Ulrich and Cooper, nov." appears. This is a lapsus for *Trematorthis*, which is correctly spelled in all other parts of the text. Page proof in the writer's possession bears the correct heading *Trematorthis*.

NEW GENERA AND SPECIES

Longispina Cooper, n. gen.

Small, quadrate in outline; hinge forming widest part; concavo-convex; costate; ventral posterior margin provided with a few long spines extending outward nearly parallel to the hinge.

Ventral interior with strong teeth; delthyrium open; dental plates absent; muscular field large and with flabellate diductor impressions. Dorsal interior with elongate, compressed and bilobed cardinal process. Brachial processes obsolete, median ridge low. Pseudopunctate.

Genotype: *Chonetes emmetensis* A. Winchell, Rep. Lower Peninsula Michigan, 1866, p. 92. Winchell's types redescribed and figured by Ehlers and Kline, Contr. Mus. Paleont. Univ. Michigan **4** (10): 156, 1934. Reference specimens U.S.N.M. nos. 108206a-d.

Differs from *Pliochonetes* Paeckelmann in great length of spines, absence of brachiophores, and presence of a median ridge. Species assigned here are: *Chonetes mucronatus* (Conrad), *C. robustus* Raymond, and *C. vicinus* (Castelnau).

Institella Cooper, n. gen.

Subrectangular in outline with hinge equal to about greatest shell width. Ventral valve with convex umbo, but anterior to the umbo appears a deep, narrow-sulcus that extends anterodorsally as a long sharp tongue. Flanks bounding sulcus convex with steep slopes to lateral margin. Dorsal valve with sulcate umbo, but anterior to umbo a narrow carinate fold occurs that rises anterodorsally to meet the ventral tongue. Lateral margins of ventral valve with a frill extending ventrally and outward. Dorsal valve with corresponding ventrally and outwardly directed frill. Ventral valve with short interarea and small delthyrium under the low beak.

Ventral interior with large flabellate diductors occupying deep cavities on each side of the median ridge formed on the inside by the sulcus. Adductors small, elongate, crenulate and located anterior to delthyrium on the median ridge.

Dorsal valve with thin median septum occupying internal groove produced by exterior fold. Adductor field small, located just anterior to cardinal process. Brachial impressions as in *Dictyoclostus* but small. Cardinal process erect bilobed.

Ventral valve with prominent spines along posterior margin and cardinal extremity where largest ones are located. Dorsal valve without spines. Surface costellate and reticulate.

Genotype: *Productus leonardensis* R. E. King, Univ. Texas Bull. **3042**: 70, pl. 14, figs. 4–9. 1930. Reference specimens U.S.N.M. nos. 108549a-f.

Differs from *Dictyoclostus*, which it resembles externally, by the extravagant lateral flanges, the deep sulcus, carinate dorsal fold, and cardinal area of ventral valve.

Costellirostra Cooper, n. gen.

Subtriangular in outline, dorsal valve deeper than the ventral one, ventral beak with minute foramen just posterior to apex. Uniplicate; ventral valve with long anterior tongue. Valves multicostellate, impunctate.

Ventral interior with short concave deltidial plates; teeth stout, supported by callus. Muscular field elongate oval with large diductor impressions. Adductors nearly central, attached to small platform. Dorsal interior with long thick cardinal process; myophore having two long outer prongs and two shorter inner ones. Crura short and stout, extending anteroventrally from base of shaft. Median ridge long and thick.

Genotype: *Atrypa peculiaris* Conrad, 5th Ann. Rep. Geol. Surv. New York, 1841, p. 56. Reference specimens U.S.N.M. nos. 95547a, 108209a-c.

Differs from *Eatonia* by its multicostellate ornamentation, more flabellate ventral muscular area and more extravagantly developed cardinal process. Other species are *E. singularis* (Vanuxem) and *E. tennesseensis* Dunbar.

Paurorhyncha Cooper, n. gen.

Large, subtriangular, with unequally deep valves, the ventral one slightly convex but the dorsal one very deep; uniplicate; multicostellate.

Ventral interior with much reduced dental plates and small teeth. Muscular area small, elongate-oval. Foramen minute, beak closely pressed onto dorsal umbo. Deltidial plates vestigial. Dorsal interior with long median septum supporting a small V-shaped chamber to which the divided hinge-plate is attached. Socket plates elevated, crural bases concave, often swollen.

Genotype: *Rhynchonella endlichi* Meek, Bull. U. S. Geol. Surv. Terr. (ser. 2) 1: 46. 1875. Syntype U.S.N.M. no. 7798a; dorsal interior U.S.N.M. no. 108213.

Differs from *Leiorhynchus* in the presence of a deep V-shaped chamber. From *Plethorhyncha* it differs in the slighter development of the dorsal median septum, smaller ventral muscular field and mode of thickening of hinge-plate.

Sedenticellula Cooper, n. gen.

Small, rhynchonelloid, with ventral sulcus and dorsal fold. Surface multicostate with costate increasing in number by intercallation. Ventral interior with sessile spondylium; dorsal interior with long median septum, and small cruralium divided by a median septum.

Genotype: *Camarophoria hamburgensis* Weller, Bull. Geol. Soc. Amer. 21: 500. 1910.

Distinguished from *Camarophoria* by its leiorhynchoid exterior and sessile spondylium.

Brevispirifer Cooper, n. gen.

Medium sized, generally longer than wide, with hinge equal to or slightly wider than midwidth. Valves costate, lamellose; fold and sulcus noncostate.

Ventral interior with strong, short, flaring dental plates. Muscular area oval. Dorsal socket-plates confined to sides of valve and attached to floor by short supporting plates. Cardinal process absent.

Genotype: *Spirifer gregaria* Clapp, in Hall, 10th Rep. New York State Cab. Nat. Hist., 1857, p. 127. Reference specimens U.S.N.M. nos. 108216a-c.

This genus suggests *Mucrospirifer* but is longer than wide and possesses supporting plates in the dorsal valve. Besides the type, *S. lucasi* Stauffer and *S. davisi* Nettelroth are assigned here.

Fimbrispirifer Cooper, n. gen.

Wider than long with narrowly rounded sides; valves multicostate with fold and sulcus costate. Entire surface marked by concentric lamellae, each bearing a single row of small spines. Ventral interior with strong dental plates. Dorsal interior with shallow narrow socket-plates that converge toward the center and join a callosity under the beak. Median ridge low.

Genotype: *Spirifer venustus* Hall, 10th Rep. New York State Cab. Nat. Hist., 1857, p. 133. Reference specimens U.S.N.M. nos. 39489a, 108217a.

Suggests the completely costate *Costispirifer* but differs in presence of concentric lamellae and spines and inside the dorsal

valve in the presence of short supporting plates. *Paraspirifer* possesses similar spiniferous lamellae but the fold and sulcus are noncostate. *S. divaricatus* Hall and *S. grieri* Hall belong here.

Costispirifer Cooper, n. gen.

Large, spiriferoid in outline and profile; multicostae with costate fold and sulcus. Costae flat and marked by fine radial costellae. Ventral teeth small, dental plates short and thick. Delthyrium covered by a short convex pseudodeltidium. Dorsal valve with stout, shallow socket plates restricted to the side of the valve and supported by callus only.

Genotype: *Spirifer arenosus planicostatus* F. M. Swartz = *Costispirifer planicostatus* (Swartz), U. S. Geol. Surv. Prof. Paper 158-C: 56. 1929. Reference specimens U.S.N.M. nos. 97942a-c, 97943a, b.

Differs from *Fimbrispirifer* by its broad flat costae, covered by radial costellae and absence of any plates supporting the socket plates. *Spirifer arenosus* (Conrad) and *S. unicus* Hall are also placed here.

Dimegelasma Cooper, n. gen.

Large, spiriferoid in outline and profile with smooth fold and sulcus; flanks costate. Shell substance coarsely endopunctate. Ventral interior with long, strong dental plates. Delthyrium partially covered by a flat delthyrial plate. Muscular field long and oval. Dorsal valve with crural bases attached to sides of valve and united medially to a short low septum.

Genotype: *Spirifer. neglectus* Hall, Geol. Surv.Iowa 1 (pt. 2): 643, pl. 20, fig. 5. 1858. Reference specimens U.S.N.M. nos. 49163a, b; 108218.

Differs from the Permian genus *Spiriferella* with which it has been confused by its endopunctate shell, elongate dental plates, and flat delthyrium. The Russian *Spiriferella* is impunctate, the dental plates are short, and the pseudodeltidium is convex.

Spondylospira Cooper, n. gen.

Shell cyrtinoid in outline with costellate fold and sulcus. Ventral valve hemipyramidal, delthyrium open; surface of interarea deeply striated at right angles to the hinge, the ridges between the striae representing growth tracks of teeth on the hinge margin. Interior of ventral valve with dental plates and median septum grown together to form a cyrtinoid spondylium, in which the median septum extends posterodorsally into the chamber formed by the spondylium. Dorsal interior with short and low median ridge, small crural bases. Descending lamellae of spire supported by a calcareous net. Shell substance punctate, exterior granulose.

Genotype: *Spondylospira reesidei* Cooper, n. sp.

Resembles *Cyrtina* in outline and profile but differs in having a costate fold and sulcus, dentate cardinal edge, no deltidial plate, and the descending lamellae of the spire supported by a calcareous net. Besides the genotype, *Spiriferina alia* Hall and Whitfield and *Cyrtina lewesensis* Lees are placed here.

Spondylospira reesidei Cooper, n. sp.

Small, cyrtinoid in outline and profile; wider than long. Ventral valve hemipyramidal, beak often twisted. Costae bifurcating anteriorly. Sulcus shallow, occupied by a costa that bifurcates near the front margin. Fold low, formed by a single costa on the umbo. This costa bifurcates about 2½ mm anterior to the beak. The two costae thus produced then bifurcate near the middle of the valve to produce four costae, which extend to the margin. Flanks marked by six to nine costae.

Ventral interior with high median septum, and shallow spondylium. Dorsal interior having united jugum and descending branches of spire united to floor of valve by a calcareous net.

Holotype: U.S.N.M. no. 10346a. Paratypes: U.S.N.M. nos. 103468b-g.

Triassic (Seven Devils formation), east side of Mission Creek, 1½ miles above Mission, 4½ miles above Jaques, about sec. 15, T. 36 N., R. 3 W., Nez Perce County, Idaho.

Spondylospira reesidei differs from *S. alia* by its smaller size and stronger costae; it differs from *S. lewesensis* in having fewer costae in the fold and sulcus and more on the flanks.

Cryptothyrella Cooper, n. gen.

Large, elongate, lenticular in lateral profile, elliptical to subcircular in cross section. Anterior commissure rectimarginate to uniplicate. Beak strongly incurved; foramen minute, apical. Dorsal beak fitting into a concave plate under ventral beak. Surface smooth, shell substance impunctate.

Ventral interior with long divergent dental lamellae on each side of the elongate triangular muscle field. Dorsal interior with long median septum supporting divided hingeplate. Brachidium with compressed spiral cones and inverted Y-shaped jugum, the tail of the Y directed posteroventrally.

Genotype: *Whitfieldella quadrangularis* Foerste, Kentucky Geol. Surv. Bull. 7: 327, pl. 1, figs. 4a-c. 1906. Syntypes U.S.N.M. no. 84891.

Differs from *Whitfieldella* by the minute foramen, large triangular muscular field, and the elongate form of the valves.

Plectoconcha Cooper, n. gen.

Terebratuloid, generally rotund and longer than wide; uniplicate with superimposed alternate multiplication. Foramen large, permesothyrid, labiate. Deltidial plates not exposed.

Ventral interior with large strong teeth not supported by dental plates. Pedicle collar strong. Cardinalia with strong, inner socket plate and deep sockets. Crural bases thin short, crural process attached at end of hinge-plate. Loop short and wide, descending lamellae short and flaring laterally; transverse ribbon slightly arched.

Genotype: *Rhynchonella aequiplicata* Gabb, Geol. Surv. California, Pal., 1: 35, pl. 6, fig. 37. 1864.

Externally resembles the Permian *Hemiptychina* but differs in not possessing dorsal septal plates and in the shorter, wider loop.

Oleneothyris Cooper, n. gen.

Large, sulcate, with smooth exterior. Beak erect, foramen large, mesothyrid, marginate to labiate. Deltidial plates concealed in adults.

Ventral hinge teeth supported by callus only; ventral muscular area pyriform in outline, situated anterior to the teeth. Cardinalia with strong, high inner socket ridges corrugated on the surface facing the socket; exterior hinge-plates short, moderately concave and united with a short crural base extending posteriorly nearly to the cardinal process. Crural processes moderately long, bluntly pointed; descending lamellae short and stout, produced anteriorly into moderately long processes. Transverse band directed slightly posteriorly and strongly ventrally to form an inverted V. Cardinal process large. Dorsal adductor scars located near the middle of the valve and lying anterior of a low and wide median ridge, pyriform in outline and fairly large.

Genotype: *Terebratula harlani* Morton, Amer. Journ. Sci. 18: 250, pl. 3, fig. 16. 1829. Reference specimens U.S.N.M. nos. 559395–559397.

Differs from *Terebratula* s.s. in having a greater development of inner socket ridges, broader crural bases, stouter crural processes, and the transverse band of loop in form of an inverted V.

Choristothyris Cooper, n. gen.

Shell thick, small, subcircular in outline with a narrow, slightly curved hinge. Anterior commissure sulcate, surface multicostate to plicate. Beak suberect to erect; foramen large, submesothyrid; deltidial plates small, disjunct.

Ventral interior with large teeth having deep fossettes in callus supporting them. Muscular area large and flabellate, divided by a low but stout median ridge. Cardinalia strong with inner socket ridges strong and high, bounding deep and wide sockets. Hinge-plates small, concave. Crural bases short and stout; loop terebratelliform with long slender crural processes. Cardinal process ponderous. Adductor impressions on each side of a high, thin median septum reaching to the center of the valve.

Genotype: *Terebratula plicata* Say, Amer. Journ. Sci. 2: 43. 1820. Reference specimens U.S.N.M. nos. 2395, 103556.

Differs from *Terebratella* in its angularly costate exterior and cardinalia. The hingeplate of *Terebratella* is deeply concave and united with the median septum, and its cardinal process is a small callosity at the

beak. The cardinal process of *Choristothyris* has a strong shaft with trilobed myophore occupying the space between the crural bases.

Atrypella shrocki Cooper, n. sp.

Shell of about average size for the genus, slightly longer than wide; lateral margins rounded, anterior margin truncated. Greatest width at about the middle. Dorsal valve the deeper, and with gentle convexity in lateral profile but strongly convex in anterior profile. Ventral valve with strongly incurved beak; gently swollen in the umbonal and medial regions but depressed in the anterior third to form a shallow sulcus; ventral tongue short, bent almost at right angles to the lateral commissure and with narrowly rounded extremity. Dorsal valve with short narrowly rounded fold in the anterior third somewhat tumid in the median region and with steep slopes to the lateral margins. Surface smooth. Measurements of holotype: Length, 18 mm; width, 16.7 mm; thickness, 11.6 mm.

Holotype: U.S.N.M. no. 108210a. Paratype: U.S.N.M. no. 108210b.

Horizon and locality: Silurian (Huntington limestone), SE¼SW¼ sec. 29, T. 27 N., R. 1 E., 3 miles east-northeast of the bridge over the Wabash River at Georgetown, Indiana. Named after Dr. R. R. Shrock, who discovered the species.

Suggests the common *Atrypa phoca* Salter of the Arctic but differs in having a more elongate outline, deeper sulcus, narrower and more elevated fold, and less convex dorsal valve.

Trigonirhynchia sulcata Cooper, n. sp.

Uncinulus stricklandi (auct. not Sowerby) Bassler, U. S. Nat. Mus. Bull. **92**: 1312. 1915.

Large, subtriangular, slightly wider than long with greatest width in anterior third. Lateral margins curving gently to the narrowly rounded anterolateral extremities. Anterior margin straight. Surface marked by 20–26 costae, 6–9 on the fold, 7–9 on the flanks.

Ventral valve shallow, gently and evenly convex in lateral profile. Sulcus broad and shallow, originating in posterior third; tongue long, anteriorly rounded and bent at right angles to the valve surface. Flanks narrowly convex. Beak small, pressed onto the dorsal umbo.

Dorsal valve the deeper, posterior half most convex in lateral profile, anterior half nearly flat. Fold low, defined in the front half, flanks gently convex and very steep-sided.

The holotype has a length of 30 mm, width of 32 mm, thickness 23.7 mm, and width of fold of 19.5 mm.

Holotype: U.S.N.M. no. 108553.

Horizon and locality: Waldron shale, Waldron, Indiana.

This species has been generally identified with *Uncinulus stricklandi* (Sowerby) of the British Silurian but differs in its wider and shallower sulcus and narrower, less strongly defined fold.

LITERATURE CITED

BAYLE. *Explication carte géologique France*, Atlas. 1878.

BILLINGS, E. *On some fossils from the Primordial rocks of Newfoundland*, Canadian Nat. Geol., n. ser., **6** (4). 1872.

COOPER, G. A., and J. S. WILLIAMS. *Tully formation of New York*. Bull. Geol. Soc. Amer. **46**. 1935.

DALL, W. H. *Index to the names which have been applied to the subdivisions of the class Brachiopoda*. U. S. Geol. Surv. Bull. **8**. 1877.

GEORGE, T. N. *The British Carboniferous reticulate Spiriferidae*. Quart. Journ. Geol. Soc. **88**. 1832.

HALL, J. *Catalogue of the species of fossils described in Volumes I, II, and III to the Palaeontology of New York*. 12th Ann. Rep. New York State Cab. Nat. Hist. 1859.

———. *Contributions to paleontology*. 13th Rep. New York State Cab. Nat. Hist. 1860.

——— and J. M. CLARKE. *Introduction to the study of the genera of the Palaeozoic Brachiopoda*. Paleont. New York **8** (2). 1894.

MEEK, F. B. *Paleontological report. Descriptions of new species of fossils*. 6th Ann. Rept. U. S. Geol. Surv. Terr. 1873.

——— and A. H. WORTHEN. *Geology and paleontology*. Geol. Surv. Illinois **3**. 1868.

ÖPIK, A. *Über einige Dalmanellacea aus Estland*. Acta et Comment. Univ. Tartuensis (Dorpatensis, **A25**. 1933.

PANDER, C. H. *Beiträge zur Geognosie des russischen Reiches*. 1830.

SCHUCHERT, C., and G. A. COOPER. *Brachiopod genera of the suborders Orthoidea and Pentameroidea.* Mem. Peabody Mus. Nat. Hist. **4** (1). 1932.
SCHUCHERT, C., and C. M. LEVENE. *Brachiopoda.* Fossilium Catalogus. 1929.
ULRICH, E. O., and G. A. COOPER. *Ozarkian and Canadian Brachiopoda.* Geol. Soc. Amer. Special Papers **13**. 1938.
WALCOTT, C. D. *Cambrian Brachiopoda with descriptions of new genera and species.* Proc. U. S. Nat. Mus. **28**. 1905.
——— *Cambrian Brachiopoda.* Mon. U. S. Geol. Surv. **51**. 1912.

GEOLOGY.—*Atlantic coastal "terraces."*[1] RICHARD FOSTER FLINT, Yale University. (Communicated by G. ARTHUR COOPER.)

The problem of the Pleistocene[2] "terraces" along the Atlantic coast of the United States from New Jersey to Florida breaks down into three subsidiary questions: (1) How much of the Coastal Plain was covered by the sea at any time during the Pleistocene? (2) What definite strandlines are present? (3) What is the cause of the striking difference in Pleistocene deposits and topography between the regions north and south of the James River? On all three questions confusion of marine features with fluvial features must be avoided. Each of these questions will be considered briefly:

Area covered by the sea.—Three lines of evidence help to fix the area covered by the sea at one time or another: *sediments, fossils,* and *topography.*

SEDIMENTS appear to be better size-sorted in the marine littoral zone than under most stream conditions, and they commonly contain less ferruginous and kaolinitic material than do stream deposits. Types of stratification may be much the same in both marine and fluvial deposits, but cut-and-fill bedding is certainly fluvial and not marine. Judged on these characters, the sediments below an altitude of about 100 feet in southern Virginia and below 160 feet in Georgia appear to be mainly marine, whereas nowhere north of the James River do sediments that are thought to be marine occur higher than 50 feet.

Between the James River and Florida the average grain size of the Pleistocene sediments is finer than the surface exposures indicate, for borings and rare deep cuts exhibit a change downward from the common surface sand and silt to stratified silt and clay. The coarse surface sediments may represent offlapping deposits laid down in the littoral zone.

FOSSILS: No Pleistocene marine fossils had been reported from the Atlantic Coastal Plain from altitudes higher than 28 feet until Hyyppä found a marine diatom flora in a deposit, apparently Pleistocene, sampled by Stephen Taber near McBeth, S. C., with a surface altitude of about 70 feet.[3] Surface samples are commonly barren, but the finer subsurface sediments in the region south of the James River offer a promising field for diatom studies as borings and other excavations open them up.

TOPOGRAPHY: The evidence afforded by topography is good. Cooke, Monroe, and others have described bars and swales in various districts between the James River and Florida. The bars are numerous and massive and include hooked spits. They occur as high as 100 feet altitude in southern Virginia, 180 feet in Georgia, and 240 feet in north-central Florida. In general, they become more numerous and more massive from the James River southward. None has been reported from the region north of the James at altitudes greater than 50 feet.

These bars are marine features without doubt, but they do not fix the sea *levels* of the times when they were built, because the tops of bars that are being fashioned by the sea at present occur through a wide range of vertical positions extending well above and well below the surface of the sea itself.

Definite strandlines.—Ordinarily it is easier to determine that the sea has stood

[1] Received May 25, 1942.

[2] For the purposes of this paper, the Pleistocene is considered to represent the time from the Pliocene to the present.

[3] Flint, R. F., *Pleistocene features of the Atlantic Coastal Plain.* Amer. Journ. Sci. **238**: 780. 1940.

over a broad territory than to fix the positions at which its shore stood during appreciable pauses. The best evidence—perhaps the only satisfactory evidence—of the latter consists of wave-cut cliffs or scarps facing the sea. In identifying such features in the weak materials of the Coastal Plain we must set aside all river-facing scarps as being possibly stream-cut, and we can not make use of the numerous bars because their tops may have stood above or below sea level.

Fortunately there are two definite wave-cut scarps, recognized in Virginia by Wentworth and elsewhere by Cooke: the Surry scarp and the Suffolk scarp. The Surry scarp is 15 to 35 feet high and has a slope of 1° to 2½°. It separates a dissected surface to landward, from a less dissected and much more gently sloping surface to seaward. It occurs discontinuously from the James River to the Savannah River, a distance of 375 miles, and throughout this distance its toe stands at an altitude of 90 to 100 feet. The suffolk scarp has a maximum height of 60 feet and a maximum slope of 5°. Its discontinuous length is greater than that of the Surry scarp, because it continues south into Florida. Its toe stands at 20 to 30 feet. This scarp is believed to be younger than the Surry scarp because it is fresher and is not blanketed by later sediments.

The discontinuities in both scarps are due in part to lateral subaerial erosion but chiefly to lack of original development, (*a*) back of bars, and (*b*) near the mouths of large rivers. It seems likely that these rivers built sediments into the sea faster than the waves could remove them, and that thus significant cliffing by the waves was prevented.

The sea must have stood, at least briefly, at many levels other than those recorded by the Surry and Suffolk scarps, and perhaps clear evidence of other shorelines will be discovered, though apparently it has not yet been established. The burden of proof that other shorelines are present must rest with those who postulate such features.

Striking differences between the regions south and north of the James River.—From the James River south to Florida there is satisfactory evidence from sediments, fossils, and topography of Pleistocene marine encroachment reaching 100 feet near the James and reaching higher altitudes farther south, and, in addition, topographic evidence of two long stillstands of the sea. On the other hand, from the James River north through New Jersey, undoubted marine deposits are present up to an altitude of only 30 feet. The tops of bars stand somewhat higher, but generally at higher altitudes we find stream sediments, and, along the rivers, stream-cut terraces. It appears likely that while the Surry scarp was being cut in the region south of the James River, the Potomac, Susquehanna, and Delaware River systems were building alluvium into the sea farther north. At that time the shoreline probably lay east of the present Chesapeake Bay and Delaware Bay shoreline. It seems likely that later, as emergence and perhaps unwarping occurred, this alluvium was dissected and reworked by these same rivers, and that the alluvium, largely reworked, is represented today by the Beacon Hill, Bridgeton, and Pensauken sediments in New Jersey and the Sunderland, Wicomico, and Talbot sediments in Maryland and Delaware. The Suffolk scarp appears to postdate these events and is probably the correlative of the Cape May sediments and shore features in New Jersey.

The features described here are marine plains, marine bars, inconspicuous scarps, and fluvial plains. As none of them is properly a terrace, this term is misleading. To be sure, the area lying between the toe of the Surry scarp and the toe of the Suffolk scarp has a terrace-like form, but its width is so great compared with its height that this form becomes conspicuous only when represented by a profile with the vertical dimension exaggerated. For this reason it seems best either to inclose the word *terrace*, as applied to these features, in quotation marks, to show that although frequently used it is not appropriate, or to avoid using it altogether.

An independent problem concerns the dates of origin of the Suffolk and Surry scarps. As these features are warped little if at all, probably they record fluctuations

of sea level rather than crustal movements. As they lie higher than present sea level, probably they date from interglacial rather than glacial times. According to current estimates, if all existing glaciers were to melt, the sea would rise to somewhere near the level of the Surry scarp. Perhaps, therefore, this scarp records a complete deglaciation. Judged on this basis, the Suffolk scarp would record a much less complete deglaciation. There is evidence, as shown by Mansfield and Cooke, that between Surry time and Suffolk time there was an interval when the sea level was lower than at present, perhaps indicating a glacial age. The broad wave-cut bench[4] that surrounds the island of Bermuda with a maximum present depth of 65 to 75 feet below sea level may perhaps be a record of this same post-Suffolk interval of lower sea level.

It is certain that the sea has not stood higher than the altitude of the toe of the Suffolk scarp at any post-Suffolk time. Hence it may be inferred that the Suffolk scarp represents the latest interglacial time of any consequence—possibly the Peorian interglacial sub-age. In this case the Surry scarp might be tentatively considered to represent the Sangamon interglacial age. No direct evidence bearing on this dating, however, is known to the writer.

MacClintock[5] suggests that the Cape May formation in New Jersey, which the writer considers to be the correlative of the Suffolk scarp, is of Sangamon date. If this dating were correct, the Surry scarp would have to be referred to an earlier interglacial age, probably the Yarmouth. But until additional facts become available, this matter remains in the realm of speculation.

[4] Sayles, R. W., *Bermuda during the Ice Age.* Proc. Amer. Acad. Arts and Sci. **66**: 447. 1931.

[5] MacClintock, P., *Marine topography of the Cape May formation.* Bull. Geol. Soc. Amer. **51**: 2002. 1940.

BOTANY.—Hugelia *Bentham preoccupied.*[1] LOUIS CUTTER WHEELER, University of Pennsylvania. (Communicated by EDGAR T. WHERRY.)

The polemoniaceous genus *Hugelia* Bentham in Edwards's Botanical Register **19** (n. s., vol. 6): t. 1622. 1833, is recognized by some authors, e.g., Jepson, Man. Fl. Pl. Calif., 792–793. 1925?, though others, e.g., Munz, Man. So. Calif. Bot., 393, 401–402. 1935, Craig, Bull. Torr. Bot. Club **61**: 385–396, 411–428. 1934, and Macbride, Contr. Gray Herb. n. s. **49**: 51–58. 1917, consider it as only a subdivision of the genus *Gilia* Ruiz & Pavon. Brand in Engler, Pflanzenreich IV. 250: 164–168. 1907, placed it under *Navarretia* as a subgenus. There seems to be no published consideration of the effect of Article 61 of the International Rules of Botanical Nomenclature, ed. 3, 1935, on the use of *Hugelia* Bentham as a genus. The provisions of Article 61 are: "A name of a taxonomic group is illegitimate and must be rejected if it is a *later homonym*, that is if it duplicates a name previously and validly published for a group of the same rank based on a different type. Even if the earlier homonym is illegitimate, or is generally treated as a synonym on taxonomic grounds, the later homonym must be rejected."

In publishing *Hugelia*, Bentham made the following explanation in a footnote: "In honour of Baron Charles de Hügel of Vienna. Hugelia of Reichenbach is Didiscus *D. C.*"

It has been difficult to trace the preoccupying *Hugelia*. Various references are given in indices and nomenclators. Much weary delving has unearthed a work in which the genus was defined, after a fashion. The genus commemorated the same man as did Bentham's, merely differing in spelling by an umlaut over the "u"; therefore *Hügelia* is a mere orthographic variant of *Hugelia*, the names are homonymous under the terms of Art. 61, Note, and the later of the two must be rejected.

The bibliographical data are: *Hügelia* H. G. L. Reichenbach, Iconographia Botanica Exotica sive Hortus Botanicus Imagines Planatarum, t. 201, p. 2. 1828–1830. The genus is defined in observations

[1] Received June 6, 1942.

at the top of page 2 of the text for plate 201 by telling how it differed from *Trachymene* Rudge. Included was only *Hügelia coerulea*, based on *Trachymene coerulea* Graham, Edinb. New Philos. Journ. 5: 380. 1828 (July–Sept. number). It is quite possible that *Hügelia* Reichenbach was published earlier elsewhere. On page 1 of the text for plate 201 Reichenbach cites: "201. Hugelia coerulea Rchb. Conspect. regni veget. n. 3760. C. et Mittheil. a. d. Geb. d. Flora, n. 13. p. 50." The first half of this reference is readily interpreted; but in the well-known Conspectus, 144. 1828, the genus is undescribed, and a footnote refers to "Hugelia cyanea Jc. exot. 201. planta ex elegantissima." The second part of Reichenbach's reference proved difficult to elucidate, and the publication involved has not been located. The reference was finally explained upon consulting the Allgemeines Bücher Lexikon by Wilhelm Heinsius, Achter Band, Erste Abtheilung, von Otto August Schulz. 1836. On page 3 the entire reference is given as follows: "Abend-Zeitung. Mit ein. Wegweiser im Gebiete d. Kunste u. Wissenschaften. Hrsg. v. C. S. Th. Winkler (Th. Hell.) Nebst. e. artist. Notizenblatte v. C. A. Böttiger. 12–18. Jahrg. 1828–34. kl. Fol. Dresden, Arnold.

"12. Jahrg. m. d. Beibl.: Einheimisches. 13. J. m. d. Beibl.: Mittheil. a. d. Gebiete d. Flora u. Pomona, red. v. H. G. L. Reichenbach."

It appears that vol. 13 of what seems to have been a botanical and horticultural supplement to the evening paper of Dresden probably was published in 1829 if volumes 12–18 appeared 1828–34. (The common impression that publication of names of plants in newspapers is ineffective seems to be without support in the International Rules of Botanical Nomenclature.) If this newspaper supplement were really published in 1829, the Iconographia Exot. Bot. t. 201 was probably not published earlier than that year. It is going to require considerable bibliographical delving to establish the exact date of publication of the several parts of the Iconographia. However, for purposes of the present paper, it is only necessary to show that *Hügelia* Reichenbach was published prior to *Hugelia* Bentham (1833). Two copies of the Iconographia with Centuria III (of which only 50 plates were published) have been examined. The first, kindly lent by the Arnold Arboretum, has all three centuries bound together. The fascicle covers are missing and there is no title page for Cent. III. The title page of the entire work gives the dates as 1827–1830. The second, examined in the library of the Academy of Natural Sciences of Philadelphia, has the three centuries bound separately, each with its own title page, and even the original fascicle covers are preserved. However, this copy seems to be a German edition, for there is a brief German text in front of the Latin text for Cent. III and the synonymy, at least, for the Latin text, is abbreviated. The date of publication on the title page of Cent. III is given as 1827–1830. The fascicle cover of Cent. III bears no date. (Pritzel, Thes. Lit. Bot. ed. 2 does not mention a German edition.) In absence of proof to the contrary, the date given in a work must be accepted (Rules, Art. 45). Furthermore, there is contemporary evidence that plate 201 appeared prior to 1833, since Otto August Schulz in Wilhelm Heinsius, Allgemeines Bücher Lexikon, Achter Band, Zweite Abtheilung (covering books published 1828–1834) p. 147. 1838, stated, concerning the Iconographia, that Centuria III, Fascicles 1–5, were published in Leipzig in 1828–1830.

Having thus established that *Hugelia* Bentham is preoccupied, the next consideration is the propriety of conserving this genus. The case is not impressive as the genus is small, comprising, according to Craig, a recent monographer, only 8 species; is of no consequence horticulturally; and is often considered a mere subdivision of *Gilia*. Moreover, the preoccupying genus may have priority over *Didiscus* DC., in which event the name *Hugelia* were properly reserved for that umbelliferous genus.

Being deemed unworthy of conservation, the next question is, what is the valid name for *Hugelia* Bentham? According to Brand, *Welwitschia* Reichenbach, Handbuch, 194. 1837, was the next generic name published

for the group, but this is a *nomen rejiciendum* in favor of the famous gymnospermous *Welwitschia* Hooker f., Gard. Chron. 1862: 71. 1862. According to both Macbride and Craig, the next generic name is *Eriastrum* Wooton & Standley, Contr. U. S. Nat. Herb. 16: 160. 1913, which was substituted for *Hugelia* Bentham 1833 on the ground that De Candolle had used *Hugelia* in 1830. The fact that in DC. Prod. 4: 72. 1830, *Hugelia* Reichenbach was cited in synonymy does not affect the validity of Wooton & Standley's generic name.

This study was undertaken at the instance of Prof. Edgar T. Wherry, who in connection with review of the Polemoniaceae of certain western states desired to use names for taxonomic groups in accordance with current rules of nomenclature.

Conclusion: *Hugelia* Bentham, 1833 (Polemoniaceae), is preoccupied by *Hügelia* Reichenbach, 1828–1830 (Umbelliferae). The proper name for the polemoniaceous genus, provided it be deemed worthy of generic rank, is *Eriastrum* Wooton & Standley, 1913.

ENTOMOLOGY.—*The genus* Ferdinandea *Rondani*.[1]

FRANK M. HULL, University of Mississippi. (Communicated by ALAN STONE.)

The genus *Ferdinandea* comprises a small group of closely related species of flies of the subfamily Cheilosinae from the Holarctic region and as far south as Sumatra. None are known from South America, the Ethiopian region, or Australia. There are 14 described species, including those of this study. Eight dipterists have described the known species, and the European species have been frequently redescribed.

In this genus the opacity of the abdomen varies; almost all species, with the exception of *montana*, n. sp., are partly or wholly metallic; the hyalinity of the wing varies from unspotted in *isabella*, described in this paper, to characteristic tiny clouds upon the cross veins or larger subtriangular clouds, as in three species. These flies are well equipped with long bristles upon the thorax but vary in the number of scutellars, prescutellars, and especially notopleurals, as pointed out by Shannon. There is a certain amount of variation in the large thoracic bristles, and sometimes the number on the two respective sides of the same individual differs. In some individuals one member of a pair of bristles may be quite weak. Other characters concern the color of the antennae and arista, the color of the legs, and the diffuse and obscure spot sometimes found upon the face. There is a series of two to seven tiny microbristles found upon the radial sector of the wing.

[1] Received January 1942.

The following key is based upon my study of nine species and upon the descriptions and figures of the others:

KEY TO THE DESCRIBED SPECIES OF *FERDINANDEA*

1. Segments of abdomen entirely bright brassy colored, without any trace of darker posterior borders. Thorax with four notopleural bristles on each side, in groups of two; rarely with fewer.....2
   Abdomen usually metallic, always with darker posterior borders (not necessarily opaque) upon some of segments; two or three notopleural bristles present, very rarely if ever with four.....4
2. Wing with cross veins definitely clouded, occasionally faint.....3
   Wing without trace of clouds anywhere; only stigmal base brownish and wing uniformly pale yellowish brown. Four notopleural bristles, four scutellars, and four prescutellars; radial sector with two microbristles (India).....*isabella*, n.sp.
3. Four notopleural bristles; an obscure facial vitta present, which is sometimes only a spot upon tubercle; femur wholly yellowish or its basal half brown; four pairs of scutellars, one weak pair of prescutellars, five or six microbristles (western United States).....*croesus* O. S.
   Two or three notopleurals, or irregular upon the two sides; femur wholly pale yellow; face yellow, tubercle faintly brown, cheek spot barely indicated; scutellum with five pairs of bristles (Arizona).....*croesus* var. *midas*, n.var.
4. Abdomen yellowish brown, nonmetallic; at least second and third segments with black, wedgelike spots; cross veins of wing without brown clouds; antennae wholly black. Thorax with three pairs of

notopleurals, five scutellars, and one pair of prescutellars; seven microbristles present (India).....*montana*, n.sp.

Abdomen partly or largely metallic, with dark posterior borders; wing almost always clouded, at least upon cross veins. 5

5. Wing with a brownish cloud or a triangle lying on and below stigma.....6

Wing with only cross veins clouded.....8

6. Three pairs of notopleural bristles; arista reddish basally, darker apically; postmargins of second and third abdominal segments black; petiole beyond first posterior cell shorter than discal cross vein. Face yellow, pollinose, and pilose except upon brown tubercle; femora brown, yellowish apically, anterior tibia brownish (Oregon, New Mexico).....*aeneicolor* Shannon

Not such flies.....7

7. A strong brown cloud below stigma of wing; antenna reddish, arista brown; scutellum brownish red, black pilose, with five pairs of scutellars and four prescutellars (Malaya).....*maculipennis* Curran

A weak brown cloud beneath stigma; third antennal joint brownish black; scutellum waxy yellow (Sumatra).....*sumatranus* de Meij.

8. Abdomen short and broad, highly shining purplish bronze, hind border of segments 2 and 3 shining blackish; spots on cross veins of wings faint or absent (Formosa).....*formosanus* Shiraki

Abdomen relatively slender, the cross bands subopaque or at least dull; cross vein wing spots usually conspicuous...9

9. At least base of arista pale in color, often thickened and microscopically pubescent.....10

Arista wholly blackish or brownish black, rather slender.....13

10. Pile of front and vertex chiefly black; mesonotum with some black pile; dull abdominal bands premarginal, posterior margins brassy (Europe, from Sweden to Spain and Italy)....*ruficornis* Rondani

Pile of front and mesonotum pale yellow, at most light brown. Two pairs of notopleural bristles.....11

11. Three pairs of black scutellar bristles, a single pair of weak prescutellars, and five microbristles on wing (Virginia, New Jersey, Pennsylvania, New York).....*buccata* Loew

Four or five pairs of scutellar bristles; face with a brownish-black V in middle; vertical stripes of pubescence rather wide..12

12. Legs yellow; cross veins strongly clouded, seven microbristles on wing; arista black tipped, longer than antenna. Four and sometimes five scutellars and four weak prescutellars (New Jersey, Ohio, Pennsylvania, Massachusetts, New Hampshire, Connecticut, Mississippi).....*dives* O. S.

Hind legs with femur brownish black on its basal half, cross veins weakly clouded; arista wholly pale, thick basally, as long as antenna; four scutellars, four very weak prescutellars, and five or six microbristles (New York, New Hampshire, Massachusetts).....*nigripes* O. S.

13. Face with a blackish middle stripe or at least a dark central spot; thorax with four gray vittae (southern Europe).....*aurea* Rondani

Face wholly reddish yellow; if brown upon the tubercle there are only two gray stripes on thorax.....14

14. Vertex entirely black; thorax greenish black with four gray vittae; four notopleurals, five pairs of scutellars, four strong prescutellars, six microbristles present; frontal and mesonotal pile black (Japan, Europe from Sweden and Finland to Italy).....*cuprea* Scop.

Vertex yellow; thorax purplish black with two gray stripes (Bulgaria, Hungary).....*sziladyi* Drensky

Ferdinandea croesus Osten Sacken var. **midas,** n. var.

An individual from southern Arizona shows several differences from northwestern specimens of *croesus* O. S. in my collection. In this fly there are only two notopleurals on one side and three upon the other. The scutellum has five pairs of bristles, and there are only four in northwestern specimens. The femur is wholly pale yellow. The face is yellow, with the tubercle showing faintly brown; the cheek spot is barely indicated.

Type: One male, southern Arizona; author's collection.

Ferdinandea montana, n. sp.

Male: Length 12 mm; wing 11 mm. *Head:* Eyes quite pilose, the vertex gray-pollinose with long, gray bristly hairs. Occiput gray-pollinose with pale silvery pile, rather short above, longer below. Front densely silvery-gray pollinose, a bare black lunule above the antennae on each side. Face wholly pale yellowish pubescent or pollinose, continuing upon the cheeks; everywhere pale yellow in ground color except for the median brown stripe and tubercle and the slender brown band dividing the face from the cheeks. Pile of cheeks and upper sides of face pale, shining yellow, upon the front

black. Antenna dark blackish brown, the third joint rather large, slightly subquadrate, the arista long and black. *Thorax:* Dully shining grayish black with four stripes of light greenish-gray pollen; the middle pair broad, running to the base of the scutellum and in some lights divided into an inner and outer pair, the inner pair narrower and present only on the anterior half of the thorax. Humeri light brownish yellow, yellow-pollinose; humerus and pleuron and a narrow band along the anterior margin of the mesonotum, again upon the postcallus, the ventral margin and lateral corners of the scutellum all yellow-pilose. Pile of dorsum chiefly long, slender, black, and erect, with some shorter, golden pile. There are three extremely long black bristles on the sides before the suture, four on the sides of the thorax behind the suture and anterior to the posterior calli; a single bristle diagonally in front of the posterior calli, a pair of bristles in front of the scutellum, three bristles upon each posterior callus and five pairs upon the scutellum. Scutellum large, pale yellow, subtranslucent, black bristly pilose. *Abdomen:* Grayish yellow, subtranslucent on the first segment and middle and base of second segment, elsewhere on the abdomen clear, light brownish yellow, with a median blackish vitta on each of the second, third, and fourth segments that does not reach the posterior margin. Pile of abdomen chiefly light golden-yellow, long and bushy on the sides of the segments, rather flat and appressed along the posterior margins of second, third, and fourth segments and somewhat less appressed in the middle of these segments. *Legs:* Almost wholly pale yellow, the base of both the middle and anterior femur, dorsally and anteriorly, narrowly brown in color. Posterior femur rather slender. There are a few blackish bristles but not spines upon the apical fourth of the outer, lateroventral portion of the femur. There is a pair of bristles near the middle on the lateral surface of both hind and midtibiae. *Wings:* Pale brown, stigmal cell brownish yellow, a series of seven tiny bristles on the basal part of the second and third longitudinal vein.

Holotype: One male, Kashmir, Gulmarg, 8,500 feet, summer, 1913. Lt. Col. F. W. Thomson, 1914–12; three paratypes, females, same data. Type in the British Museum; paratypes in author's collection.

Ferdinandea isabella, n. sp.

Female: Length 11 mm; wing 10 mm. *Head:* Vertex and occiput yellowish-brown pollinose. Front shining black, with more or less gray pollen, narrowly brown along the margin in front of the antennae. The whole face and cheeks are light, clear yellow, slightly more brownish red about the tubercle and the posterior part of the cheeks. Face broadly covered with pale yellowish pubescence. Antenna large, light brownish red, the third joint darker above, about as long as wide and broadly rounded; the arista blackish. Eyes moderately pilose. *Thorax:* Shining brassy-black, with four stripes of grayish pollen. Pleuron blackish, dusted with grayish pollen and with brassy pile. Humeri light yellow, yellowish pollinose and pilose. There is long yellow pile continued narrowly along the edge of the thorax, along the calli and the basal corners and ventral margin of the scutellum. Pile of thorax chiefly fine, bristly, and black, with some pale pile intermixed. Scutellum large, clear, translucent yellow, short, black, bristly pilose; three long black bristles on the upper part of the mesopleuron, two others between the mesopleuron and the suture, a pair just behind each humerus, two on the sides of the thorax just above the wing, three on each postcallus, one in front of each postcallus, four in front of the scutellum, and four pairs on the scutellum. *Abdomen:* Broadly oval, wider than the thorax, wholly brilliant, shining golden-brown, covered everywhere with golden pile, somewhat appressed and conspicuous along the posterior margins of the segments. *Legs:* Pale yellow. The anterior and middle femur are each narrowly brownish near the base. The hind femur is quite slender, blackish, bristly pilose on the lateral and dorsal surfaces; its apical third is without spines. The basal and dorsal third of hind tibia and its apex are black bristly pilose. *Wing:* Pale brown, stigmal cell brownish yellow, the area about the stigma a little thickened and brownish. Base of second and third longitudinal vein with two slender delicate black bristles.

Holotype: One female. Kashmir, Gulmarg, 8,500 feet, summer 1913, Lt. Col. F. W. Thomson, 1914–182. Type in the British Musum.

ZOOLOGY.—*Earthworms of the Northeastern United States: A key, with distribution records.*[1] THEODORE H. EATON, Jr., Cornell University. (Communicated by G. ARTHUR COOPER.)

In the States east of the Mississippi River and north of Virginia about 17 species of native earthworms are found, with about 13 more believed to have been introduced from Europe. They belong to four families; the great majority, including all the introduced species, are Lumbricidae. Information about these earthworms is too scattered to be of much help to a general biologist, agronomist, or forester who wishes to identify the species he finds or uses in the laboratory. Most of the papers on earthworms are taxonomic and concerned with a small area or with a limited group. It seemed, therefore, that a key based so far as possible on external features, and accompanied by descriptive and distributional notes, might be useful.

Distribution records already published are cited by State or country, followed by an abbreviation in parentheses of the author's name and the year of publication, given in full in the bibliography. Names thus abbreviated are the following: Gates (G), Heimburger (H), Olson (O), Smith (S).

Distribution records given as new are based upon specimens that I have collected or have seen in collections, and for the determination of which I therefore am responsible. The sources of these are likewise abbreviated in parentheses. (E) refers to my own collection; (AM) the collection of the American Museum of Natural History, specimens being lent through the kindness of Dr. W. G. Van Name, associate curator of invertebrates; (FC) the collection made by Dr. C. E. Johnson, of the New York State College of Forestry, Syracuse, courtesy of Professors Ralph T. King and W. A. Dence; (NM) the United States National Museum collection, courtesy of Dr. Waldo L. Schmitt; (NY) the New York State Museum collection, Albany, kindness of Dayton Stoner, State zoologist. To the institutions and persons named I am much indebted for the opportunity to study these specimens.

[1] Received April 7, 1942.

INTRODUCED VERSUS NATIVE EARTHWORMS

It is the opinion of the specialists on earthworms (e.g., Michaelsen, 1903; Smith, 1928; Gates, 1929; Stephenson, 1930) that while an individual worm can not travel far by its own activity, nevertheless some species are carried very frequently for long distances by human agency, as among the roots of plants shipped for horticultural purposes, and thus are introduced into foreign countries. In Santiago, Chile, for instance, Michaelsen found thousands of worms of familiar European species to one native Chilean, but when he collected in the interior, in small towns less subject to European contacts, he found many Chilean species as well. Likewise in western Australia European species of Lumbricidae are practically the only earthworms found near towns. In India, Ceylon, New Zealand, South Africa, and elsewhere in European settlements, the same is true. Apparently the introduction of these adaptable and hardy kinds may cause the decline or disappearance of local species.

In the United States, species that are well known in Europe have appeared at widely separated points, such as San Francisco, New York, and Illinois, and at least in a few cases (Smith, 1928) they are known to have spread since their first discovery, increased in numbers, and to a large extent replaced American species. The predominant family in Europe and North America is Lumbricidae, which accordingly is suited to climatic changes. One abundant species, *Allolobophora caliginosa*, survives equally well winter temperatures of 40°–50° below zero in northern New York, and summer heat of 120° in the shade in the Punjab Province of India. In Europe and North America the chance of being transported by land or by sea is relatively great because of the amount of trade and travel. It would be surprising, therefore, if Lumbricidae were not introduced into new habitats much

more frequently than some of the tropical families of earthworms.

American species have appeared in Europe at least twice: *Sparganophilus eiseni* in the banks of the Thames; *Eisenia carolinensis* at Hamburg.

It must be left to later studies to determine what effect introduced earthworms have upon soil and soil productivity. That they are introduced and do live successfully where Europeans settle has not been questioned seriously.

FEATURES OF EARTHWORMS

Fig. 1 shows the more obvious external characters of a sexually mature *Lumbricus terrestris*. A good hand lens, or better still a low-power dissecting microscope, is necessary to see many of these. Earthworms are hermaphroditic, but fertilization of the eggs

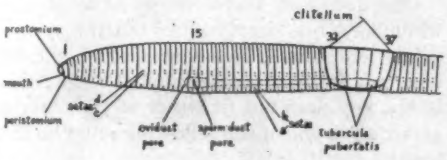

FIG. 1.—External characters of sexually mature earthworm (*Lumbricus terrestris*).

is accomplished by an exchange of sperm between one individual and another; afterward each of the pair releases its own eggs into a small capsule, which is secreted by its girdle or clitellum and slips off over the forward end. Most of the characters used in identifying species appear only in mature worms. Therefore it is necessary to collect individuals that have a clitellum, although immature ones from the same location can often be identified by their general resemblance to the mature.

CHARACTERS INDEPENDENT OF SEXUAL MATURITY

Condition of the prostomium.—This is the first apparent segment of the body. It is not counted as a segment because it lies above and in front of the mouth and does not contain the usual segmental organs. On the upper (dorsal) surface the prostomium may send a tongue backward on the surface of the first true segment (peristomium). If this tongue goes all the way to the following groove, completely dividing the top of the peristomium, then the worm is practically certain to be a species of *Lumbricus*. If the peristomium is not completely divided on top, it belongs to another genus.

Arrangement of setae.—The minute bristles or setae of an earthworm number eight to the segment in the kinds found in the Northeastern States, although some southern and tropical worms have a great many more. These eight are usually in four pairs, as shown in the figure, but in some species the pairing is so distant that they are described as separate, or widely paired. The four setae on each side occupy about the same positions in successive segments and therefore form four rows running lengthwise. These rows, beginning with the most ventral, are called *a*, *b*, *c*, and *d*.

Color.—Most earthworms are pale pinkish, with little pigment or none. Others are dark reddish brown or purplish (*Lumbricus*, *Sparganophilus*). In these pigmented kinds the color is heaviest at the forward end and on the upper side. Often a dark line runs along the dorsal side. This is in part the dorsal blood vessel, which lies above the digestive canal, close to the body wall. Worms sometimes show iridescence, or physical color (bluish or purple) independent of pigment. A conspicuously green worm is *Allolobophora chlorotica*.

CHARACTERS DEPENDENT ON SEXUAL MATURITY

Clitellum.—In a zone covering several segments the cuticle becomes raised and smooth, so that intersegmental furrows wholly or partly disappear. The number of segments covered may be determined by looking on the ventral surface, which as a rule is not affected, or the tips of the setae may be visible through the swollen girdle. It is almost always necessary to determine, by counting, which segments bear the clitellum. Some species are extremely constant in this feature (*Octolasium lacteum*), others vary as much as three or four segments one way or the other, so that addi-

tional characters are required. In the key the location of the clitellum is given by the numbers of the first and last segments it covers; e.g., 25, 26–29, 30 means that it begins on 25 *or* 26 and goes to 29 *or* 30.

Tubercula pubertatis.—On each side of the clitellum near its lower edge may appear a series of two or three small swellings on successive or alternate segments, or a ridge reaching three or four or five segments. Their location is within the limits of the clitellum, but they are sometimes absent. If on alternate segments the numbers are separated by colons; e.g., 31:33:35; if in a ridge or on adjoining segments, a dash is used; e.g., 28–30.

Openings of sperm ducts.—In the majority of North American earthworms the sperm ducts open low on each side of segment 15, thus in front of the clitellum, but there are several exceptions to this. Also species sometimes differ in the presence or absence of a swelling or papilla at the opening of the duct.

Openings of oviducts.—As a rule these are very small pores, one on each side of segment 14, lower than the sperm duct opening. They are less frequently used in classification.

Spermathecae (or seminal receptacles) are internal pouches which receive the sperm from another individual. Their pores open on the upper part of each side in the grooves between certain segments, which are designated as grooves 8/9, 9/10, etc., meaning those between 8 and 9, between 9 and 10, and so on.

Sperm sacs (or seminal vesicles) are the internal pouches which hold the sperm produced by the same individual, prior to its discharge. They can only be seen by dissection. When present they are usually in some or all of segments 9–12.

USE OF THE KEY

In using the following key to identify an unfamiliar species, one should read first the statement marked *A*, and decide whether it fits the worm; if not, go to *AA*. If this then agrees, make a similar choice between *B* and *BB*, then *C* and *CC*, and so on, until the name of the species is reached. In a few cases there are three alternatives presented, as in the genus *Allolobophora: I*, *II*, and *III*. In such a case one is to be chosen.

In "running down" a worm that turns out to be *Lumbricus terrestris*, for example, we would meet the following characters:

AA. Not threadlike; segments less than 250.
BB. Clitellum begins behind 15; sperm duct pores in front of clitellum.
CC. Prostomium completely divides peristomium . . .
DD. Clitellum begins behind 28; sperm duct pores with distinct papillae.
E. Clitellum 32–37; tub. pub. 33–36 . . .

One does not, therefore, go through the whole key, but simply picks out the appropriate choices. If a contradiction should come up, so that the specimen at some point in the key does not fit either of the choices given, then one of the following must be the case:

1. It is a species not hitherto known from this region.
2. It is an abnormal variation, such as may spoil a key character perhaps once in a hundred times.
3. A mistake has been made at a previous point in the key.
4. The key is at fault, which is entirely possible.

For localities outside the Northeastern States this key will not be satisfactory because other species may be found. Characters given in the key should not be taken as adequate for genera or families.

KEY TO EARTHWORMS OF NORTHEASTERN STATES, WITH DISTRIBUTION RECORDS

A. Threadlike; segments 400–500; length 12–21 cm. Setae in 2 ventral and 2 dorsal rows (each side), the dorsal sometimes absent. Clitellum ring-shaped. . . . . *Haplotaxis emissarius* (Forbes, 1890). HAPLOTAXIDAE

Fairmont, Ind., Havana, Ill., Hampton, Va. (NM); Ohio (O, '28). These slender worms, pale red and iridescent when alive, are aquatic, living in underground water, marshes, and wells. Native.

AA. Not threadlike; segments less than 250.
B. Clitellum begins at or in front of segment 15. Sperm duct pores behind clitellum.
C. Clitellum on 13–18; setae widely paired. . . *Diplocardia* Garman, 1888. MEGASCOLECIDAE

D. Clitellum a complete girdle. Length 5–10 cm. ..... *D. singularis* (Ude, 1893)

Indiana (H, '15); Illinois (S, '28); Ohio (O, '28). This species is reported from stream banks and under logs; scattered, but locally common. Native.

DD. Clitellum not a complete girdle.

E. Sperm duct pores on 19.

F. Spermathecal pores in grooves 6/7–8/9. Last hearts in 12. Length 20–30 cm. ..... *D. communis* Garman, 1888

Illinois (S, '28); southwestern Ohio (O, '28). *Diplocardia communis* is described as common in upland soil about Urbana, Ill., but less numerous since the introduction of the European *Lumbricus terrestris* about 1896. Native.

FF. Spermathecal pores in grooves 7/8, 8/9. Last hearts in 13. Length 20–25 cm. ..... *D. riparia* Smith, 1895

Indiana (H, '15); Illinois (S, '28); central Ohio (O, '28). This worm is reported in wooded pastures, rich bottomland, along streams or beside ponds. Native.

EE. Sperm duct pores on 20; length 7–15 cm. ..... *D. verrucosa* Ude, 1895

Illinois (S, '28); Nebraska (G, '29). Native.

CC. Clitellum on 15–25; setae closely paired; sperm duct pores on 19. ..... *Sparganophilus eiseni* (Smith, 1895). GLOSSOSCOLECIDAE

Indiana (H, '15); Illinois (S, '28); Ohio (O, '28); New York (O, '40); Massachusetts, Florida, Michigan, Wisconsin, Louisiana, Mexico, Guatemala (G, '35). New records: Squaw Bay, Lake Erie (NM); Ashokan, New York (AM); north shore Oneida Lake, New York, marshy stream edge (FC); West branch Fish Creek, below Kasoag Lake, Oswego County, New York, under stone at edge of water (FC); edge of Susquehanna River, 4 miles southwest of Owego, New York, in wet mud (E). Ithaca, New York, wet mud (E). This is a slender species, 15–20 cm long, with 165–220 segments, pink with a bluish or purplish sheen when alive. It lives in very wet mud, beside or in streams or lakes. There is a record of its occurrence in the Thames River, England, probably by introduction from the United States. Native.

BB. Clitellum begins behind 15; sperm duct pores in front of clitellum ..... LUMBRICIDAE

C. Prostomium does not completely divide peristomium.

D. Clitellum begins in front of 30.

E. Clitellum does not reach as far back as 28 ..... *Eiseniella tetraedra* (Savigny, 1826)

Massachusetts, Pennsylvania, Ohio, Indiana, Illinois, Michigan, Colorado, California, Washington (G, '35); New York (O, '40). New records: Cascadilla gorge, Ithaca, New York (13, 15. E); banks of Susquehanna River below Owego, New York (13, 15. E); highly organic mud beside pond, Waverley, New York (13. E); edge of creek, McLean bogs, Tompkins County, New York (13. FC); Cedarvale, New York, under stones, edge of creek (15. FC); Pratts Falls, Onondaga County, New York, along creek (11, 13. FC); Cascades near Collingwood, Onondaga County, New York (11. FC); Bronx County, New York City (11, 13. AM); Edgewater, New Jersey (13. AM); Meech's Island, Shelburne, Vermont, in lake, under stones (NY); Rock Creek Park, Washington, District of Columbia, near creek, in wet mud (13. E). European. The numbers in parentheses refer to the segment bearing the sperm duct pores in various specimens. This is a variable feature in *Eiseniella tetraedra;* several "varieties" have been named according to this and the position of the clitellum, which likewise varies:

Clit: 22 or 23–26 or 27	Spd. pores 13	*typica*
Clit: 23 or 24–27, 28, 29	Spd. pores 15	*hercynia*
Clit: 20 or 21–24 or 25	Spd. pores 11	*kammoniensis*
Clit: 20 or 21–24 or 25	Spd. pores 13	*neapolitana*
Clit: 20 or 21–24 or 25	Spd. pores 15	*ninnii*

Since two or more of these varieties often occur together in one locality, they are probably not subspecies but standardized individual variations, like the black and cinnamon bears. Probably the difference is due to assortment of genetic allelomorphs. The species is small, usually 3–6 cm, and the posterior part has a four-cornered rather than cylindrical form in most specimens. It has a wide range in the Old World. The preferred habitat is wet or polluted banks of streams and ponds.

EE. Clitellum reaches at least as far back as 28.

F. Spermathecal pores dorsal to seta line *d* ..... *Eisenia* Malm, 1877

G. Setae widely paired, ab:bc:cd = 5:9:5 ... *E. veneta hortensis* Michaelsen, 1890

Europe, Africa, South America, San Francisco, California (S, '17), Cleveland, Ohio (G, '42). A stream-bank species, Illinois (S, '28). European. The clitellum is on 26, 27–32, 33; tubercula pubertatis 30–31; spermathecal pores in grooves 9/10, 10/11; segments 80–120; length 4–10 cm.

GG. Setae closely paired.

H. Spermathecal pores in furrows 8/9, 9/10, 10/11; clitellum 24–30. ..... *E. lönnbergi* (Michaelsen, 1894)

Georgia, North Carolina, Virginia, Maryland, Massachusetts (G, '35); Connecticut (G, '42). Native. The record from Massachusetts refers to a white pine-hemlock-hardwood forest.

HH. Spermathecal pores in furrows 9/10, 10/11.

I. Each segment ringed with a brown line; clitellum 24, 25, 26–32; tub. pub. 28–30, 31 ..... *E. foetida* (Savigny, 1826)

Europe; introduced into the United States where it is common and widespread. New records: Compost heaps, Onondaga Hill, New York (FC); Syracuse, New York (FC); Brooklyn, New York, under humus and rotten vegetables (AM); in rubbish heap and humus, Bergen Beach, New York (AM); Edgewater, New Jersey (AM); Ashokan, New York (AM); Kenwood, New York, under log in earth (NY); Howes Cave, New York (NY); pasture, streambank, Ithaca, New York (E). The published records of habitats include manure heaps, sewer outlets, polluted stream-banks, decaying straw, dead logs, and similar places where moisture and organic content are both high. The length is 6–13 cm, and the banded appearance is the most obvious character of this worm.

II. Segments not ringed with brown.

J. Tub. pub. 29–31; clitellum 24, 25, 26–31, 32, 33.. *E. rosea* (Savigny, 1826)

Europe, Maine, New York, Georgia, Indiana, Illinois, Louisiana, Arizona, California (S, '17); Ohio (O, '28). European. New records: Pratts Falls, Onondaga County, New York, under stones by creek (FC); Syracuse, New York, in "heap of clay," on sidewalks, and in alfalfa field (FC). The length is 3–8 cm, the color pale pinkish. A general characteristic of preserved specimens is that the clitellum is swollen to about twice the diameter of the adjacent parts of the body.

JJ. Tub. pub. 27–29; clitellum 24–31 ..... *E. carolinensis* Michaelsen, 1903

This species was described from a specimen introduced with plants into Hamburg from Fayetteville, North Carolina (S, '17), a second example of transfer from America to Europe. Native. Length 3.5 cm.

FF. Spermathecal pores, if present, in or ventral to seta line *d*.

G. More than 2 pairs of sperm sacs; spermathecae present.

H. Setae closely paired; sperm sacs in 9–12 ..... *Allolobophora* Eisen, 1874

I. Tub. pub. 31:33 or 31–33; clitellum 24, 25, 26, 27, 28–32, 33, 34, 35 ..... *A. caliginosa* (Savigny, 1826)

Europe; the most abundant, widespread, and ecologically adaptable species in the United States. New records: (New York) Along brook in pasture below Cascades, south of Collingwood, Onondaga County (FC); alfalfa lot, Syracuse (FC); Pack Forest, Warrensburg (FC); Whetstone Gulf, stream side (FC); Jamesville, Onondaga County (FC); Junius Ponds area, Ontario County (FC); Ithaca: Fall and Cascadilla gorges, lawns, McGowan woodlot (E); dry ditch beside field, and bank of Susquehanna River, below Owego (E); Rose, Wayne County, in coarse mull and in woody peat (virgin and cultivated) (E); Potter, Yates County, in woody peat (E); Palmyra, Wayne County, in coarse mull under hardwood forest (E); McLean, Tompkins County, in fine mull in forest (E); Newcomb, Essex County, in grassy fields (E); New York City (AM). (Pennsylvania) Polluted stream bank, Sayre (E). (New Jersey) Alpine, Palisades near Edgewater, Edgewater (AM). This species shows a variability similar to that of *Eiseniella tetraedra*, in that two "varieties" have been named. But the distinction here concerns the tubercula pubertatis: in var. *typica* they are separate swellings on 31:33; in var. *trapezoides* they form ridges extending from 31–33. In many specimens it is difficult to decide which condition is present, and the two forms very generally occur together. In New York State *trapezoides* seems to be slightly more frequent. In Ohio (O, '28) and Illinois (S, '28) it is described as much more abundant than *typica*. The clitellum also varies in position, being most frequently about 27–34. Again I do not believe that these differences have subspecific value, since neither in Europe nor in America are they geographically significant, but suggest rather that one or more pairs of genetic allelomorphs may be responsible, the proportions varying among different populations of the species. The use of trinomials would then be misleading. This worm is pale pinkish; length 6–17 cm.

II. Tub. pub. 32–34; clitellum 27, 28–35 ..... *A. longa* Ude, 1885

Europe, Maine, Grand Manan, Toronto, Indiana (S, '17); Connecticut (G, '42). New records: Region of New York City (AM); Brooklyn, New York, under stones, humus, rotten vegetables (AM); pasture near McLean bogs, Tompkins County, New York (E). In size and general appearance this species is much like *A. caliginosa*. Only determination of the segments bearing the tubercula pubertatis will separate them externally.

III. Tub. pub. 31:33:35; clitellum 29–37; color greenish when alive or freshly preserved..... *A. chlorotica* (Savigny, 1826)

Europe, Greenland, Vancouver, Mexico, Guatemala, North Carolina, District of Columbia, Indiana, Colorado, California (S, '17); Ohio (O, '28); Illinois, stream banks (S, '28). New records: (New York) Syracuse (FC); Ithaca, Cascadilla gorge (E); bank of Susquehanna River below Owego, in mud and in dead wood (E); greenhouse, New York City (AM); Rensselaer (NY). (Pennsylvania) Polluted creek bank, Sayre (E). (Maryland) Bethesda (NM). This worm prefers wet and usually highly organic or polluted soil. Fresh specimens in formalin are grass-green, with a contrasting pink clitellum, which is as near as any earthworm comes to beauty. The length is 5–7 cm.

HH. Setae separate or widely paired; sperm sacs in 9, 11, 12..... ..... *Dendrobaena* Eisen, 1874

I. Clitellum 25, 26–31, 32; tub. pub. 28–30.... *D. subrubicunda* (Eisen, 1874)

Europe, Newfoundland, Niagara, Illinois, Colorado, California (S, '17); Indiana (H, '15); Ohio (O, '28); Massachusetts (G, '35). New records: Ashokan, New York (AM); Alpine, New Jersey (AM). This species is described as common in a polluted stream-bank in Illinois (S, '28). Length, 4–7.5 cm.

II. Clitellum 27, 28, 29–33, 34; tub. pub. 31–33.. *D. octaedra* (Savigny, 1826)

Europe, northern Asia, Iceland, Greenland, Newfoundland, Mexico, Colorado (S, '17); Illinois (S, '28). New record: Lake Placid, New York (FC). Length, 2.5–4 cm.

GG. Two pairs of sperm sacs, in 11, 12. Spermathecae absent (or imperfectly developed in *B. tenuis*)..... *Bimastos* Moore, 1893

H. Setae closely paired.

I. Clitellum covers less than 10 segments.

J. Clitellum begins on or in front of 23.

K. Clitellum on 23–28..... *B. palustris* Moore, 1895

Pennsylvania, New Jersey, North Carolina (G, '29). Native. This species is found in wet soil beside ponds or streams. There is a prominent swelling enclosing a cavity at the opening of each sperm duct. Tubercula pubertatis are lacking. Length, to 7.5 cm.

KK. Clitellum 20, 22–29, 30; *ab* greater than *cd*.. *B. gieseleri* (Ude, 1895)

Georgia, Florida, Ohio, Illinois, Kansas, Texas (G, '29); Indiana (O, '28). Native. Specimens from Florida and Georgia have clitellum 20–30, and are called var. *typica*. Some from Florida and those from the other States named have it located on 22–29, 30: var. *hempeli* Smith, 1915. The habitat is rotten wood, decaying logs, and leaf accumulations. Length, 5–8 cm.

KKK. Clitellum 22–29; *ab* = *cd*..... *B. tumidus* Eisen, 1874a

Mount Lebanon, New York. Native. The only record since Eisen (1874a) is a report by Olson (1940) of specimens found "near Oneida Lake."

JJ. Clitellum begins on or behind 24.

K. Clitellum 24–30; tub. pub. (indistinct) 25, 26–29, 30..... ..... *B. parvus* (Eisen, 1874a)

New York, Michigan, Kansas, California, Louisiana, Mexico, Guatemala, also China, Japan, Africa (S, '17); Ohio (O, '28); Massachusetts (G, '35). New record: Ashokan, New York (AM), not Pratts Falls (O, '40). Native. Length, 2.5–4 cm.

KK. Clitellum 24, 25–31; tub. pub. (indistinct) 24, 25–30..... ..... *B. beddardi* (Michaelsen, 1894)

Michigan, Illinois, Montana, Florida, California, Washington, Hawaii (S, '17); Ohio, near end of Lake Erie (O, '28). Native. This is found in "wet situations and in decaying logs, stumps, or moss" (S, '17).

KKK. Clitellum 25–32 (slightly on 33)..... *B. heimburgeri* (Smith, 1928)

This species is described from a specimen found in a stream bank below White Heath, Illinois. The tubercula pubertatis are apparently absent, there is very little pigmentation, and the length of the specimen is 7.7 cm. Smith notes a close resemblance to *B. palustris*.

II. Clitellum covers 10 or 11 segments.

JJ. Clitellum 23–32 or 24–33.....*B. longicinctus* (Smith and Gittins, 1915)

Urbana, Illinois (S, '17); southeastern Ohio (O, '28). Smith describes this worm as common in lawns and woods, while Olson reports it from a wet, wooded ravine, under leaves. Length, 6–9 cm. No tubercula pubertatis. Native.

JJ. Clitellum 27–37.....*B. zeteki* (Smith and Gittins, 1915)

Illinois, Indiana, Michigan (S, '17); Susquehanna River, New York (G, '29); southwestern Ohio (O, '28). Native. This species occurs in soil under logs or decaying leaves, and in dead logs under the bark. Length, 10–14 cm.

HH. Setae widely paired.....*B. tenuis* (Eisen, 1874a)

Europe, Asia, Alaska, Bering Island, Canada, Vancouver Island, Mexico, South America, Maine, New York, Ohio, Illinois, Indiana, Michigan, Colorado, California, Washington (S, '17); Massachusetts (G, '35); Connecticut (G, '42). It is difficult to judge from these records whether this species was originally North American, European, or circumpolar. The first specimens were those described by Eisen from New York State. Smith (1917) considers the European *B. constrictus* (Rosa, 1884) to be the same species. These worms favor rotting logs, decaying leaves, hay, or manure piles.

DD. Clitellum on 30–35; setae widely paired.....*Octolasium lacteum* (Örley, 1881)

Europe, Mexico, Colorado, California, Indiana, Illinois, Ohio (S, '17); Connecticut (G, '42). New records: (New York) Ithaca: Fall Creek and Cascadilla gorges (E); McLean bogs, Tompkins County, in fine black mull and in pasture (E, FC); Ringwood preserve, Freeville, Tompkins County, in leaf mat (E); Arnot Forest, Van Etten, stream side (E); Potter, Yates County; in woody peat (E); south side of Susquehanna River, below Owego, in wet decaying wood (E); Ashokan (AM); Bergen Beach (AM); Syracuse (FC); White Lake, Onondaga County (FC); Pratts Falls, Onondaga County, along creek (FC); under stones along creek, Cedarvale (FC); Cascades, Butternut Creek, Onondaga County, along brook in open pasture (FC); South Pond area, North Constantia, Oswego County (FC); Salmon River, in woods south of Parish, Oswego County. (FC). As these records show, *O. lacteum* favors, but is not limited to, moist and highly organic soil. Smith (1928) describes it as an upland and streambank species in Illinois. The length is highly variable, 5–16 cm, but the position of the clitellum combined with wide separation of the seta rows makes this species easy to recognize.

CC. Prostomium completely divides peristomium by means of an extension backward on the dorsal side, to the second furrow.....*Lumbricus* Linnaeus, 1758

D. Clitellum begins on or in front of 28; sperm duct pores without distinct papillae.

E. Clitellum on 26, 27–32; color red.....*L. rubellus* Hoffmeister, 1843

Europe, Siberia, Newfoundland, Washington, Oregon, California, Michigan (S, '17); Ohio, near Toledo (O, '28); Massachusetts (G, '35). New records: Ithaca, New York, Fall Creek gorge (E); banks of Susquehanna River, between Owego and Waverley, New York, in mud and dead wood (E); McLean bogs, Tompkins County, New York, in wet mull and in muck (E); Rose, Wayne County, New York, in woody peat, in forest (E); polluted creek bank, Sayre, Pennsylvania (E); Rock Creek Park, Washington, District of Columbia, beside stream (E). This worm seems to require a great deal of moisture and organic matter. It and the other three species of *Lumbricus* listed here are European. Length, 7–15 cm.

EE. Clitellum on 28–33; dark red.....*L. castaneus* (Savigny, 1826)

Europe, Canada, New York (S, '17); Massachusetts (G, '35); Syracuse, New York (FC). A smaller species. Length, 6–10 cm.

DD. Clitellum begins behind 28; sperm duct pores with distinct papillae.

E. Clitellum 32–37; tub. pub. 33–36.....*L. terrestris* Linnaeus, 1758

Europe, Mexico, Newfoundland, Maine, Massachusetts, New York, Connecticut, Maryland, District of Columbia, Ohio, Michigan, Illinois, Minnesota, Colorado, California (S, '17). Smith (1928) says that in Illinois this familiar species has become abundant after being first reported about 1896 and has tended to replace the native American *Diplocardia communis*. In Ohio Olson (1928) says it has become widely distributed "in the last ten years." It is present abundantly in New York State, from numerous localities, but not the Adirondack Forest so far as known. The habitats include coarse mull soil in forests or fields, mud beside streams, lawns, woody peat, and the inside of a rotten log. Length, 10–30 cm.; color, reddish brown, especially forward.

EE. Clitellum 34–39; tub. pub. 35–38.....*L. festivus* (Savigny, 1826)

This is a European species reported from Canada (S, '17), but not yet from the United States.

REFERENCES

EISEN, G. *Om Skandinaviens Lumbricider.* Öfv. Vet. Akad. Förh. **30**: 43–56. 1874.

———. *Bidrag till Kännedom om New Englands och Canadas Lumbricider.* Öfv. Vet. Akad. Förh. **31**: 41–49. 1874a.

FORBES, S. A. *On an American earthworm of the family Phreoryctidae.* Bull. Illinois State Lab. Nat. Hist. **3**: 107–116. 1890.

GARMAN, H. *On the anatomy and histology of a new earthworm* (Diplocardia communis *gen. et sp. nov.*). Bull. Illinois State Lab. Nat. Hist. **3**: 47. 1888.

GATES, G. E. *The earthworm fauna of the United States.* Science **70**(1811): 266–267. 1929.

———. *The earthworms of New England.* Proc. New England Zool. Club **15**: 41–44. 1935.

———. *Check list and bibliography of North American earthworms.* Amer. Midl. Nat. **27**(1): 86–108. 1942.

HEIMBURGER, H. V. *Notes on Indiana earthworms.* Proc. Indiana Acad. Sci. **1914**: 281–285. 1915.

HOFFMEISTER, W. *Beitrag zur Kenntnis deutscher Landanneliden.* Arch. Naturg. **9**: 183–198. 1843.

LINNAEUS, CAROLUS. *Systema naturae,* ed. 10. 1758.

MALM, A. W. Öfv. Hortik. Förh. Göteborg **1**: 45. 1877.

MICHAELSEN, W. *Oligochaeten des naturhistorischen Museums in Hamburg.* Mitt. Mus. Hamburg **7**. 1890.

———. *Die Regenwurm-Fauna von Florida und Georgia.* Zool. Jahrb., Abt. Syst. **8**: 177–194. 1894.

———. *Die Lumbriciden-Fauna Nordamerikas.* Abh. nat. Ver. Hamburg **16**: 1–22. 1900.

———. *Die geographische Verbreitung der Oligochaeten,* 186 pp. Berlin. 1903.

MOORE, H. F. *Preliminary account of a new genus of Oligochaeta.* Zool. Anz. **16**: 333–334. 1893.

———. *On the structure of* Bimastos palustris, *a new oligochaete.* Journ. Morph. **10**: 473–496. 1895.

OLSON, H. W. *The earthworms of Ohio.* Ohio Biol. Surv. Bull. **17**: 46–90. 1928.

———. *Earthworms of New York State.* Amer. Mus. Nov., No. **1090**: 1–9. 1940.

ÖRLEY, L. *A Magyarországi Oligochaetàk Faunája. I. Terricolae.* Math. Term. Közlem. Magyar Akad. **16**: 563–611. 1881.

———. *A palearktikus övben élö terrikoláknak revisiója és elteryedése.* Ertek. term. Kör. Magyar Akad. **15**: 1–34. 1885.

ROSA, D. *Revisione dei Lumbricidi.* Mem. Accad. Sci. Torino (2) **43**: 397–476. 1893.

SAVIGNY, J. C. *Analyse d'un mémoire sur les lombrics par Cuvier.* Mem. Acad. Sci. Inst. France **5**: 176–184. 1826.

SMITH, FRANK. *Notes on species of North American Oligochaeta.* Bull. Illinois State Lab. Nat. Hist. **4**: 285–297. 1895.

———. *Two new varieties of earthworms, with a key to described species in Illinois.* Bull. Illinois Lab. Nat. Hist. **10**: 551–559. 1915.

———. *North American earthworms of the family Lumbricidae in the collections of the U. S. National Museum.* Proc. U. S. Nat. Mus. **52**: 157–182. 1917.

———. *An account of changes in the earthworm fauna of Illinois, and a description of one new species.* Bull. Div. Nat. Hist. Surv. Illinois **17**(10): 347–362. 1928.

——— and E. M. GITTINS. *Two new species of Lumbricidae from Illinois.* Bull. Illinois State Lab. Nat. Hist. **10**: 545–550. 1915.

STEPHENSON, J. *The Oligochaeta.* Oxford. 1930.

UDE, H. *Über die Rückenporen der terricolen Oligochaeten, nebst Beiträgen zur Histologie des Liebesschlauches und zur Systematik der Lumbriciden.* Zeitschr. wiss. Zool. **43**: 87–143. 1885.

———. *Beiträge zur Kenntnis ausländischer Regenwürmer.* Zeitschr. wiss. Zool. **57**: 57–75. 1893.

———. *Beiträge zur Kenntnis der Enchytraeiden und Lumbriciden.* Zeitschr. wiss. Zool. **61**: 111–141. 1895.

ZOOLOGY.—*Some echinoderms from northwestern Greenland.*[1] AUSTIN H. CLARK, U. S. National Museum, and GORDON J. LOCKLEY, British Museum (Natural History).

In July and early August, 1940, Capt. Robert A. Bartlett and his associates carried out extensive dredging operations in the waters off northwestern Greenland in depths of 12 to 110 fathoms. The echinoderms brought back numbered 282 specimens representing 13 species. Although generally speaking the fauna of the shallow waters of the west Greenland seas, especially the southern portion, is well known as a result of the work of various Danish investigators and expeditions, there are still many details to be filled in and consequently all records are of value. In the present collection the most interesting specimen is the single example of *Leptasterias polaris* form *subacervata* Fisher, which, though properly referable to that form, shows a rather close approach to the form *acervata* of the region of Bering Strait. The junior author left Washington before the completion of this paper. All the identifications were rechecked by the senior author, who is therefore to be held responsible for any errors that may be found.

LOCALITIES

The localities at which echinoderms were collected were the following (unless otherwise indicated the dredging was done by Captain Robert A. Bartlett):

III.—West Turnavik, Labrador (lat. 55° 15′ N., long. 59° 20′ W.); Sam Bartlett, July 6. XV and XVI.—Melville Bay, near Thom Island; 15–80 fathoms; bottom with much kelp; Sam Bartlett and Albert Barnes, July 19. XXIV, XXV, and XXVI.—Between the north shore of Parker Snow Bay and Conical Rock; 25–45 fathoms; mostly pebbles and shells; July 22. XXX, XXXI, XXXIV, XXXVII, and XXXVIII.—About 1 mile northwest (true) of Conical Rock; 25–60 fathoms; July 22. XL, XLII, XLIII.—West side of Wolstenholme Island; about 12 fathoms; July 23. XLIV.—Off Wolstenholme Island; 13–17 fathoms; July 23. LI, LII, LV, LVII, and LIX.—Off north shore of Wolstenholme Island; 13–25 fathoms; July 23. LXXII.—Near the south end of Humboldt Glacier; 110 fathoms; D. C. Nutt, August 3.

LIST OF SPECIES

ASTEROIDEA: *Crossaster papposus* var. *squamatus* (Döderlein), XXXI (5, all with ten rays). *Stephanasterias albula* (Stimpson), XVI (6; one is almost perfectly regular with six rays 13 mm long; one has three rays 20 mm long and two buds; the others have six rays of various lengths). XXV (1, with three equal rays 10 mm long and two minute and inconspicuous buds). XXX (2). XXXI (7, of which one regenerating individual has seven rays, the others six; in some of these the skeleton is unusually slender with the interstices large, giving the animals a superficial resemblance to *Leptasterias groenlandica*). LXIII (1). LXII (5). LIX (4). Other than the exceptions mentioned, all have six rays. *Leptasterias polaris* var. *subacervata* Fisher, LII (1; R = 60 mm. In this individual the characters are much more strongly marked than in one at hand from Disco, which does not differ very noticeably from *L. p. polaris*. Both agree in having the groups of enlarged spines confined to the midradial line of the rays, and about six in number. In the specimen from Disco [R = 75 mm] the groups of enlarged spines consist of usually 7–9 spines in a circle surrounding a somewhat larger central one; but the peripheral spines are very little, if any, larger than those of the general abactinal surface. The groups of spines rise only very slightly above the general surface, and from above are noticeable only because they form usually regular rosettes in an otherwise uniformly scattered spiny armature. In the specimen from locality LII the groups of spines rise abruptly and for some distance above the abactinal surface so that they are very conspicuous in lateral view. There are 3–7 smaller spines surrounding a larger central

[1] Published by permission of the Secretary of the Smithsonian Institution and the Keeper of Zoology, British Museum. Received April 28, 1942.

one, but the lateral spines are considerably larger than those scattered over the abactinal surface so that the rosettes are very conspicuous from above. Except for the restriction of the groups of enlarged spines to the midradial line of the rays, this specimen resembles others from Bering Sea [*acervata*] more than it does any we have hitherto seen from Greenland). *Leptasterias groenlandica* (Steenstrup), XVI (1). XXXI (1). XLIII (2). LI (1). LVII (2). LIX (3; in one R = 20 mm).

OPHIUROIDEA: *Ophiacantha bidentata* (Retzius), XXV (1). XXXI (2). XLIV (2). *Ophiopholis aculeata* (Linné), III (38). XVI (3). XXV (11). XLIII (2). LII (2). *Ophiura sarsi* Lütken, XVI (4). XXV (13). XLIII (1). *Ophiura robusta* (Ayres), III (6). XVI (1). XXV (14). XXX (1). XXXI (21). XXXVII (1). XXXVIII (1). XLIII (10). *Ophiocten sericeum* (Forbes), III (6). XVI (2). XXX (5). XXXVIII (5). XLIII (1, with the disk rounded-pentagonal, 13 mm in diameter). *Ophiopleura borealis* Danielssen and Koren, LXXII (1, large, with the disk 36 mm in diameter).

ECHINOIDEA: *Strongylocentrotus droebachiensis* (O. F. Müller), XV (12; up to 55 mm in diameter; olive brown to olive green; spinulation variable, from short, dense, and fairly uniform to unequal, with the primaries long, up to 16 mm, and the secondaries short and slender). XXIV (5; up to 45 mm in diameter; test purplish black, spines bright yellow-green, or test pale dull purplish, spines dull olive green; primary spines long, up to 17 mm, secondaries slender, short, and sparse; with or without giant pedicellariae). XXXIV (9; up to 30 mm in diameter; yellow brown; primaries rather long, secondaries short and slender). XL (6; up to 43 mm in diameter; olive brown to olive green; spinulation variable, from dense and fairly uniform to sparse and unequal with long primaries and short and slender secondaries). LV (3; up to 54 mm in diameter; orange brown; spinulation diverse; numerous giant pedicellariae).

CRINOIDEA: *Heliometra glacialis* (Leach), XXV (arm fragment). XXVI (1). XL (1). LIII (5). LIV (5).

HOLOTHUROIDEA: *Cucumaria frondosa* var. *japonica* Semper, XL (4; these specimens, the largest of which is 85 mm long, contracted, have in the body wall very numerous spicules that agree perfectly with those figured by Mortensen from a specimen taken not far away; following Mortensen, we assign all the specimens from this area to this form). LI (8).

REFERENCES

CLARK, AUSTIN H. *Echinoderms collected by Capt. Robert A. Bartlett in the seas about Baffin Land and Greenland.* Journ. Washington Acad. Sci. **26**(7): 294–296, figs. 1–4. July 15, 1936.

———. *Echinoderms from Greenland collected by Capt. Robert A. Bartlett.* Proc. U. S. Nat. Mus. **89**: 425–433, pls. 58, 59. Feb. 27, 1941.

HEDING, S. G. *The Scoresby Sound Committee's 2nd East Greenland Expedition in 1932 to King Christian IX's Land. Echinoderms.* Meddel. om Grønland **104**(13): 1–68, pls. 1, 2. Feb. 25, 1935.

———. *6 og 7 Thule Expedition til Sydøstgrønland 1931–33. Echinoderms.* Meddel. om Grønland **108**(1): 1–34, figs. 1–6, Nov. 20, 1936.

MORTENSEN, TH. *The Godthaab Expedition 1928. Echinoderms.* Meddel. om Grønland **79**(2): 1–62, pl. 1. 1932 (with bibliography).

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

CHEMICAL SOCIETY

539TH MEETING

The 539th meeting (58th annual meeting) was held in the auditorium of the Cosmos Club on Thursday, January 8, 1942, at 8:15 P.M. President BEKKEDAHL presided. The annual reports of officers for 1941 were read and approved. The Society was addressed by the retiring-president, Dr. H. L. HALLER, on the subject *The search for new insecticides.*

540TH MEETING

The 540th meeting was held in the auditorium of the Cosmos Club on Thursday, February 12, 1942, at 8:15 P.M. President BEKKEDAHL presided. It was announced that Prof. M. X. SULLIVAN, of Georgetown Univer-

sity, was to be awarded the Hillebrand Prize of 1941 for his studies in the biochemistry of sulphur with special reference to the quantitative estimation of biologically important compounds. Dr. WOJCIECH SWIETOSLAWSKI, of the Mellon Institute of Industrial Research, addressed the Society on the subject *Precritical, critical, and postcritical phenomena.*

541ST MEETING

The 541st meeting and annual dinner was held in the auditorium of the Cosmos Club on Thursday, March 12, 1942, at 6:30 P.M. President BEKKEDAHL gave an account of the rules of award of the Hillebrand Prize. Dr. H. L. HALLER spoke on the history and scientific attainments of Dr. M. X. SULLIVAN, of Georgetown University, the recipient of the award for 1941, who was then presented with the Award, by President BEKKEDAHL. Dr. SULLIVAN responded with an entertaining speech of acceptance. The Society was then addressed by Dr. VINCENT DU VIGNEAUD of the Cornell University Medical School, on the subject *The conversion of methionine to cystine in the animal body.*

542D MEETING

The 542d meeting was held in the auditorium of the Cosmos Club on Thursday, April 9, 1942, at 8:15 P.M. President BEKKEDAHL presided. The society was addressed by Dr. DUNCAN A. MACINNES, of the Rockefeller Institute for Medical Research, on the subject *Electrophoretic study of proteins.*

543D MEETING

The 543d meeting was held in the White-Gravenor Building of Georgetown University on Thursday, April 30, 1942, at 8:15 P.M. President BEKKEDAHL presided. The Society was addressed by Prof. M. X. SULLIVAN, of Georgetown University, on the subject *Precision in the field of biochemistry; the quantitative estimation of important biochemical substances.*

544TH MEETING

The 544th meeting was held in the Arts and Science Building of the University of Maryland, College Park, Md., on Thursday, May 14, 1942. The meeting was preceded by a dinner in the university dining hall at 6:30 P.M. A general meeting was called to order at 8:20 P.M. by President BEKKEDAHL. The assembly was then directed to the rooms where the following divisional meetings were held.

Biochemistry, Dean Burk, Presiding

The effect of a choline-deficient diet on the production of liver tumors by p-dimethylaminoazobenzene (butter yellow): HELEN M. DYER (The George Washington University School of Medicine).

The application of the polarograph in biological chemistry: RICHARD J. WINZLER (National Cancer Institute).

Enzymic hydrolysis of purothionin: W. S. HALE, T. H. HARRIS, and B. A. AXELROD (Bureau of Agricultural Chemistry and Engineering).

Organic Chemistry, Nathan L. Drake, Presiding

The dienyne double addition reaction for the synthesis of alicyclic compounds: LEWIS W. BUTZ (Bureau of Animal Industry).

The preparation and properties of some functional derivatives of carcinogenic hydrocarbons: HUGH J. CREECH (University of Maryland).

The isolation, chemical composition, and properties of an allergenic carbohydrate-free protein from cottonseed: JOSEPH R. SPIES (U. S. Department of Agriculture).

Physical Chemistry, M. M. Haring, Presiding

Dipole moments of some organic compounds: W. J. SVIRBELY and JOHN LANDER (University of Maryland).

Color of polymethine dyes: A. L. SKLAR (Catholic University of America).

Catalyzed hydrolysis of amide and peptide bonds in proteins: JACINTO STEINHARDT (Research Laboratory of the Textile Foundation at the National Bureau of Standards).

Inorganic and Analytical Chemistry, W. L. Hill, Presiding

Complex ions of cupric nitrite in aqueous solution: A. I. KOSSIAKOFF and D. V. SICKMAN (Catholic University of America).

Determination of beryllium in biological materials: E. D. PALMES and L. T. FAIRHALL (National Institute of Health).

Distribution of copper and zinc in soils: R. S. HOLMES (Bureau of Plant Industry).